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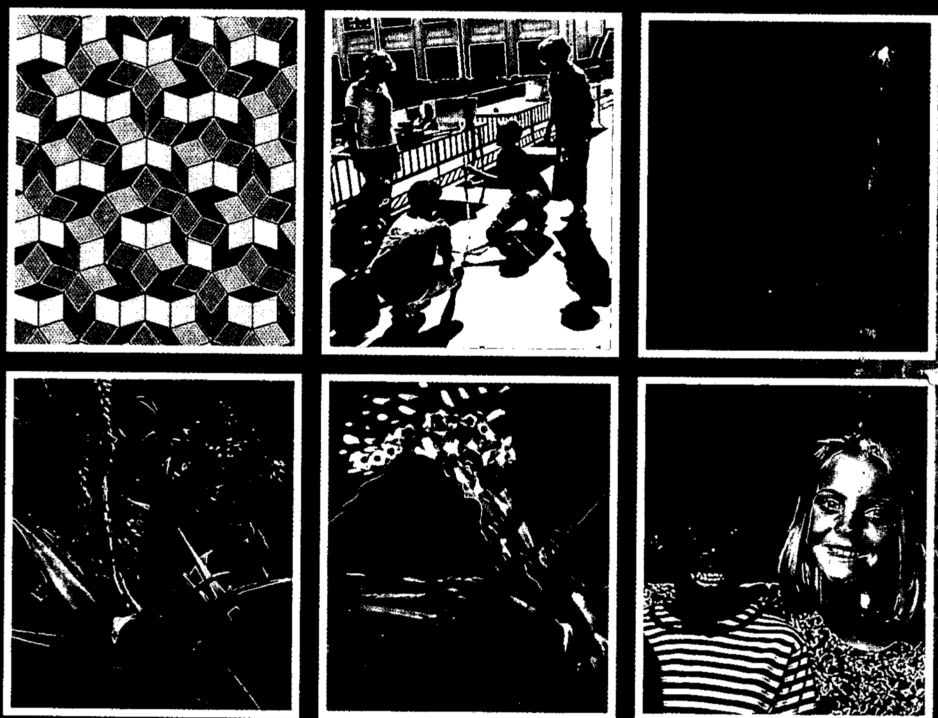
ABSTRACT

This document presents first-hand experiences of teachers and students using the Internet in K-12 math and science, as well as articles on getting the right hardware, choosing an Internet service provider, designing an online project, and fostering acceptable use. Chapters include: (1) "Something in the Air" (Linda Maston): a computer-assisted environmental investigation; (2) "Penumbra" (Greg Lockett): a cooperative astronomy project that led to one young woman finding friendship and a new mode of self-expression; (3) "Tall Shadows" (Karen Nishimoto): study of the Earth's circumference using the Internet; (4) "Pedagogically Speaking" (Bill Barnes): an online class for fourth through eighth grade math teachers examining the best kinds of cooperative activites; (5) "Hoop Happenings" (Caroline Brennan and Joanna Yantosh): math problem solving via e-mail between elementary and middle school children and college students; (6) "Confessions of a Fourth Grade Newbie" (Glenn Lidbeck): a multi-school project measuring the magnetism of the Earth at different locations using e-mail exchanges between international students; (7) "Desert Studies" (Susan Hixson): a team-taught virtual field trip; (8) "Of Wind and Weather" (Kristine Mueh): developments in teaching style through experimentations with new activities and technologies; and (9) "Expeditions to Mount Everest" (Rory Wagner): the benefits and limitations of using the Internet in project-based science as found by high school students studying earthquakes. Sidebars provide information on tools; online educational resources; and sample projects. (AEF)

TALES

FROM THE ELECTRONIC FRONTIER



first-hand experiences of teachers and students using the Internet in K-12 math and science

WESTED EISENHOWER REGIONAL CONSORTIUM

WestEd is a non-profit research, development and service agency dedicated to improving education and other opportunities for children, youth and adults, especially those most underserved. Drawing on the best knowledge from research and practice, we work with practitioners and policymakers to address education's most critical issues: from early childhood intervention to school-to-work transition, from curriculum, instruction and assessment to safe schools and communities.

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The **WestEd Eisenhower Regional Consortium for Science and Mathematics Education** (WERC) promotes systemic change of science and mathematics education in Arizona, California, Nevada and Utah. The project provides resources, consulting, and workshops in assessment, technology, standards-based reform, equity issues, content, pedagogy and partnership building. WERC also collaborates closely with the Eisenhower National Clearinghouse and the nine other Regional Consortia to provide a coordinated and field-based national infrastructure for systemic improvement.

TALES FROM THE ELECTRONIC FRONTIER

first-hand experiences of teachers and students using the Internet in K-12 math and science

Bill Barnes
Caroline Brennan
Susan Hixson
Glenn Lidbeck
Greg Lockett
Linda Maston
Kristine Mueh
Karen Nishimoto
Rory Wagner
Joanna Yantosh

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San Francisco

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COLOPHON

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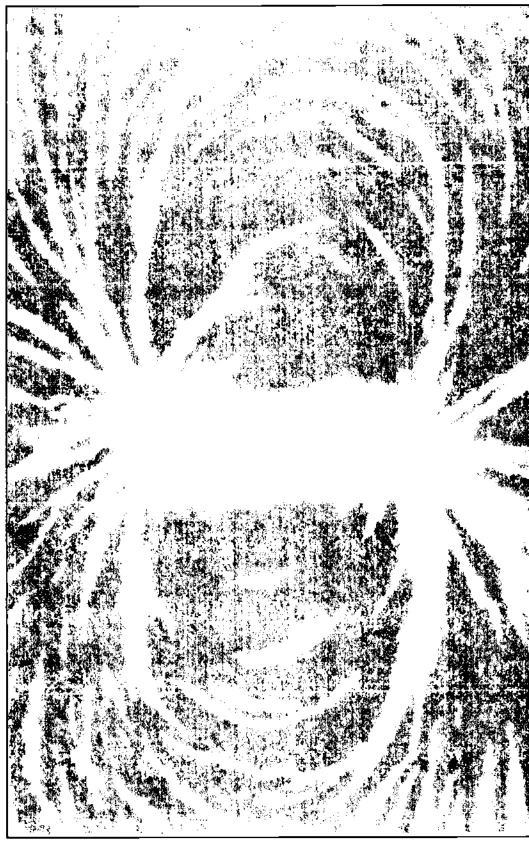
Branching Out

RESOURCES

PROJECTS

WHY TELL TALES?



The Internet is a powerful new resource teachers can use to enhance science and mathematics instruction and create opportunities for their own professional growth. At the same time, it has characteristics which define and limit its use. One way of discovering Internet benefits and drawbacks is through teachers' stories. Teachers' stories are compelling, not only because they share experiences, but because they generate inquiry. A well told story reminds us of our own experiences, encouraging us to reinterpret them from another perspective.

In *Tales from the Electronic Frontier*, ten teachers recount actual experiences using the Internet in K-12 science and mathematics education. The stories illustrate how this technology can be used in different contexts and for different purposes, stimulating analysis and reflection about how the Internet can—and cannot—support teaching and learning. Each story is followed by questions and issues generated by educators like you, prompting further thought and discussion.

Some stories focus on questions of design. What concepts do students find difficult to learn? Which online activities contribute to better understanding? In *Confessions of a Fourth Grade Newbie*, Glenn Lidbeck describes the evolution of his first online project. Realizing that fourth graders have a hard time conceptualizing the magnetism of the Earth, he creates a multi-school project to measure the Earth's magnetic field at different locations.

Other stories look at how the Internet can motivate and engage students. Linda Maston's story, *Something in the Air*, tells how poor air quality and the Internet spark student interest in science. Using inexpensive equipment and an old computer, eighth graders conduct an ingenious environmental investigation.

Pedagogically Speaking concentrates on teacher, rather than student, use of the Internet. This story, written by Bill Barnes, looks at how teachers can use this tool for professional dialogue and growth. Through his account of an online teacher forum on cooperative learning in mathematics, Bill offers insights and experiences, answering his own inimitably phrased question: how can teachers learn from one another and still manage to have a life?

Tales also touches on issues of teacher preparation and support. What resources and learning opportunities do teachers need to feel comfortable using the Internet for instruction? In *Desert Studies*, Susan Hixson collaborates with two teachers, team teaching a third grade unit on the Sonoran Desert. As they develop and implement the unit, they learn new things: how to use the Internet to support curricular goals, how to weave together real and virtual field trips, and how to publish student-generated work on the World Wide Web.

The stories in *Tales* describe teacher and student successes, mistakes and lessons learned. Rather than presuming to define characteristics of good and bad teaching, *Tales* aims to raise questions and promote inquiry. Our hope is that these stories share the information you need, helping you generate stories and experiences of your own.

BACKGROUND

Through our work in the Eisenhower Regional Consortium, we knew that teachers and students were developing ingenious ways of using the Internet in math and science. Where were these efforts chronicled? Although journals and books included first-hand accounts, none provided interconnected stories with the richness and depth we and other teachers were looking for. We decided to create *Tales* and put out a call for contributions, looking for story writers.

In January and February of 1995, over 130 teachers responded to our query, submitting short story abstracts describing how they were using the Internet in K-12 science and/or mathematics. Authors were selected according to four criteria: impact on student learning, effective use of Internet-based telecommunications, inspirational value to teachers getting started on the Internet, and readability.

Next, authors wrote and rewrote their stories with assistance from editors and from one another. Using electronic mail (email), we exchanged drafts and suggestions, sometimes supplementing messages with phone conversations or fax. It was an intense process, resulting in both friendships and lessons learned. We became better at preventing electronic miscommunication. Without the benefits of tone and inflection, the written word can be ambiguous, creating

misunderstanding. We also learned how to better match the technology to the task. Which technologies are best for exchanging charts and graphs? What is the quickest, easiest way to share student work? Through reflective writing and discussion, teachers and project staff deepened and refined their thinking about how the Internet can support teaching and learning.

USING TALES

These stories were written for the many teachers, administrators, school board members and parents involved in state and local efforts to improve science and mathematics. Whether you are an Internet newcomer or skilled online veteran, we hope *Tales* will stimulate your imagination, eliciting thoughtful inquiry into the nature of effective math and science teaching.

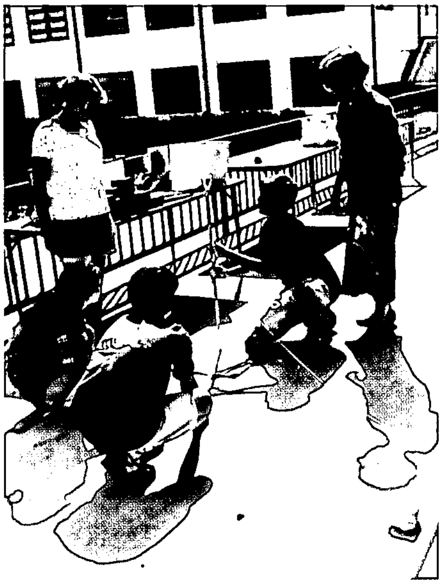
Teachers who are unfamiliar with Internet software and resources can read the stories with an eye toward visualizing opportunities and making sense of the technology. What are the different Internet software tools? How can students and teachers use them to teach and to learn?

Internet newcomers may also find it helpful to read the stories chronologically. The nine stories are arranged in three sections: Constructing a Big Picture, Starting Simply, and Branching Out. Stories in the first section illustrate the diverse nature of Internet tools and projects. Starting Simply, the second section, explores many different ways of using electronic mail, the tool most appropriate for teachers getting started. The third section, Branching Out, introduces Gopher, World Wide Web and other advanced Internet tools.

Experienced teachers can use *Tales* to explore new tools and activities, broadening the depth and range of their technology use. Stories involving Gopher and World Wide Web may offer suggestions about student projects and research. Stories which highlight teacher-to-teacher discussions may illustrate opportunities for professional growth.

Teachers and school communities already involved in group discussion can use *Tales* to determine how the Internet can support and further their work. The following suggestions for using *Tales* came from authors, project staff, and other contributors:

- For teachers involved in local and state reform efforts, *Tales* may suggest ways of enhancing existing efforts. How can teachers use the Internet to coordinate instruction across grades? How can they use this technology to support changes in practice and belief? As teachers talk about the stories, they may produce suggestions, resulting in both long and short-term suggestions for student and teacher Internet use.



- Schools involved in technology planning can use *Tales* to raise community awareness of the Internet and its educational benefits. By providing concrete examples which focus on instruction and professional growth, *Tales* can help build consensus about the potential of student and teacher Internet use, while encouraging thoughtful and balanced discussion of its drawbacks.
- University and college professors who prepare elementary and secondary school teachers can use *Tales* to supplement existing material on science and mathematics teaching methods. Through reflective group discussion, preservice teachers can develop better understandings of this technology and its role in effective math and science teaching.

GOING FURTHER

We hope you enjoy *Tales from the Electronic Frontier* and find stories that are helpful and inspiring. If and when you decide to get an Internet connection, we invite you to visit our World Wide Web site at **http://www.wested.org/tales**. *Tales on the Web*, although similar to the print version of Tales, offers additional information and resources.

We also welcome your comments and suggestions. Were there stories you found particularly meaningful or thought-provoking? Did you find the information about projects and Web sites to be useful and accurate? We'd love to hear your suggestions and any anecdotes describing how you used this publication. You can reach me by email at **mayumi_s@wested.org**.

Hope to see online...

Mayumi Shinohara

Constructing a Big Picture

SOMETHING IN THE AIR

LINDA MASTON

My eighth graders and I have one classroom computer, a pieced-together 286 PC that somehow manages to run Windows on one megabyte of RAM. Hooked up to a 2400 bits-per-second (bps) modem and phone line, it isn't exactly state of the art but we love it. It works and it gets us out—out the door to a world beyond Pease Middle School and San Antonio, Texas.

It's not that good things don't happen at Pease. They do. The faculty and staff are supportive and nurturing. The multicultural kids, many of whom are from low-income families, can be tough but they're great.

This story is about us—our problems and successes, our moments of glory and self-doubt. It's about teaching and learning in situations where resources are thin.

It was my third year participating in Global Lab (see sidebar page 7). I was excited but anxious about finding a study site. My five eighth grade classes had already completed their *indoor snapshot,* a series of environmental measurements that described the air and water quality in our classroom and school. Now I needed to decide on a new investigation, something that would build on the work the students had already done.

Other schools had wonderful, glamorous-sounding study sites: a vernal pond in Massachusetts, sections of river near a nuclear power plant, the Autobahn. But students at Pease aren't allowed to go on field trips and must stay in their classrooms during class. What could we use as *our* study site?

The answer came almost by accident. Sharing and comparing data with other schools is a big part of Global Lab. When we compared our air quality measurements with those of other schools, it became clear that something was very wrong. Our carbon dioxide (CO_2) readings were two or three times higher than everyone else's. What was going on?

I was still turning this over in my mind when I overheard several teachers talking during lunch.

"This is ridiculous. Every summer I feel fine, just great. Then I come back to school and it's nothing but sniffling and sneezing! My allergies go crazy! How the district can keep saying there's nothing wrong with the ventilation system is beyond me."

"I agree. If there's nothing wrong, then it's funny how I feel better on the weekends. I'm tired of spending all my time in the doctor's office."

That's when it dawned on me. We had a great study site—the school itself! We could investigate CO_2 levels throughout the school and correlate the readings with people's complaints!

GLOBAL LAB

Global Lab is an international network of schools linked by telecommunications, shared curriculum, and common goals. Middle and high school students practice science and investigate the environmental health of the planet.

Participating students and teachers can sample from the many Global Lab modules or can undertake the full, two semester long Global Lab curriculum. *Building Investigative Skills*, the first phase, teaches students basic investigative, collaborative and technical skills. In *Advanced Research*, the second phase, students apply their skills in open-ended investigations of local and global environmental issues.

Global Lab staff support participants by providing innovative curricula, access to professional scientists, and low-cost, high-tech instrumentation.

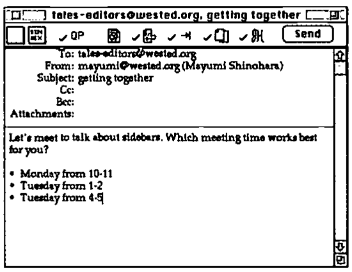
For more information contact Global Lab at:

gl@terc.edu

http://hub.terc.edu/terc/gl/GL118.html

EMAIL

Electronic mail, often referred to as email, facilitates person-to-person communication. Email can, for example, help you exchange lesson plans with teachers across the world. It can also expedite your communications with local colleagues by facilitating online discussion and making it easier to set agendas and arrange meeting times. The figure below shows a sample email window.



People choose different email software, just as they choose different word processing or desktop publishing software. It's important to choose a package that has the features you want and that also works with your computer system and Internet service provider. Begin with a call to your provider's technical support staff. What software do they recommend? What help can they offer if you run into problems? Asking these questions first can provide you with valuable information and make the process of getting started much easier.

Friday, the day I set aside to work on Global Lab, approached with great excitement for me. When I explained what we would be doing, the students started getting excited too. This was a problem they could relate to. What could be more relevant than the air we all breathe? Suddenly, everyone was talking at once. How should we go about studying the problem? When and where should we take CO_2 readings?

With minor variations, this scene was repeated throughout the day. Each group of eighth graders got involved in the mystery. I was thrilled.

Each period brainstormed a number of ways to tackle the problem. The best suggestions were assembled into an overall action plan as students formed groups and took responsibility for specific tasks.

The final plan included three main tasks: measuring CO_2, surveying teachers, and finding out what the CO_2 levels *should* be. This last task was not a popular one. Emailing other students was one thing, but *this* was something else (see sidebar this page). Nita, Caitlin and Terence—three students generally regarded as "good in science"—were finally coerced by their classmates into volunteering.

The CO_2 groups made measurements in seven classrooms over a one week period. Everyone had a job to do. Some students distributed tubes in the morning; others picked them up in the afternoon. One team of students stayed after school to develop a template for the graph. Another came in early in the morning to input the data.

Jessie was part of the data entry group. She and her friends, reluctant to participate at all, had chosen this task because "it was the easiest and wouldn't mean doing a lot of science."

So, when the time came, they grumbled a lot but began entering the data. Before long, the girls were engrossed, vying with one another to do the keyboarding and making guesses about trends in the data.

The look on Jessie's face as she pulled the first graph off the printer was just priceless!

"Oh my gosh, look at this! This is Ms. Plunkett's room! That's *my* last period class! Just *look* at the CO_2 reading it's got! And look! Just like I told you! Her room is in the middle of the hallway, really far from an outside door. Ms. Boles's room has the lowest reading and it's just inside the back door. Hey! What did Ms. Plunkett say on her health survey? Who's got the health surveys?"

Jessie wasn't the only one getting excited about surveys and CO_2 readings. Lots of teachers and students who had heard about our project asked us to monitor their rooms. Finally, we had to stop saying yes. Global Lab had donated a limited number of sampling

tubes. With a science budget of less than two dollars per student, we couldn't afford to buy any more.

Still, this schoolwide enthusiasm really paid off for us with the health surveys. The response rate was phenomenal—76 teachers out of 94 filled out our questionnaire! As soon as the surveys came in, students began compiling and analyzing the data. What were the trends? How did they match up with our CO_2 readings?

The correlations they found were astounding. 97 percent of the teachers whose classrooms had high CO_2 levels were extremely dissatisfied with the quality of their air. Teachers whose classrooms had low CO_2 levels, on the other hand, felt fine about the air they breathed—96 percent of them rated the quality of their classroom air as "excellent."

Meanwhile, Nita, Caitlin and Terence were making rapid progress in their search to determine acceptable CO_2 levels. By exchanging email with Global Lab staff, they learned two new things.

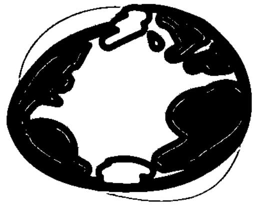
According to air quality standards published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, CO_2 levels should not exceed 1000 parts per million (ppm). Our readings indicated that CO_2 levels increased over the course of each school day, often reaching 2300 ppm by midafternoon! Furthermore, the standards described symptoms resulting from excessive CO_2 that were very similar to those documented in our health survey.

Global Lab staff also put the trio in touch with Ken Muzal, an industrial hygienist at Liberty Mutual Insurance in Boston. After a short email discussion, Ken suggested that the problem might stem from a faulty ventilation system.

EMAIL

Given the nature of your school and how it was built, I would suggest that you investigate the efficiency of your ventilation system. There are many designs that could cause inadequate ventilation, such as a flat roof with intake and out-take vents too closely spaced.

(continued page 11)



ONLINE ENVIRONMENTAL EDUCATION RESOURCES

The Internet offers curricular resources for environmental education and supports countless communities of teachers and students investigating environmental issues. Here are a few sites to help you get started.

Developed by the National Center for Environmental Education and Training, **EE-Link** shares classroom activities, projects, data sets and funding opportunities.

http://www.nceet.snre.umich.edu/

The **Global Rivers Environmental Education Network (GREEN)** helps K-12 teachers and students monitor water quality, watersheds and sustainability issues.

http://www.igc.apc.org/green/

An environmental information service for the general public, **EnviroLink** also offers an environmental education clearinghouse and other services for educators.

http://www.envirolink.org/

GETTING THE RIGHT HARDWARE

Getting connected to the Internet means making choices about hardware, software and an Internet service provider—the organization that provides your Internet service. This article deals with hardware issues: the kind of computer you will need, what a modem is and how to pick one that fits both your budget and your needs.

COMPUTER

Computers that use pictorial operating systems such as Macintosh, Windows, or OS2 provide the easiest, most intuitive Internet access. They are relatively simple to operate and can present sounds, images and video.

Older computers such as the Mac Plus and Commodore 64 can be used to access the Internet but may limit your options and be more difficult to use. These computers offer fewer software options and are not compatible with some Internet service providers. In addition, they are limited to text and cannot show graphics.

Whether you are using a hand-me-down Apple II or the latest and greatest, memory is an important issue to consider. How much RAM—random access memory, the measure of your computer's multi-tasking muscle—does your computer have? Eight megabytes (MB) of RAM are sufficient for newer Internet programs; 16 MB are preferable, and required for Windows95 and Power Mac systems. Hard disk space, also known as read only memory (ROM) or storage memory, can be a factor as well. You will need space to store the programs you use to access the Internet and to manage the information you download. If your Internet programs display only text, your needs will be fairly modest. If, however, you plan on saving complex graphics or using the latest multi-media programs, you and your students might consider expanding your storage memory to 500 MB or more.

MODEM

Modems are fairly small devices and act as translators, enabling your computer to send and receive information over standard phone lines. Attached either inside or outside your computer, they range in price depending on their speed and reliability.

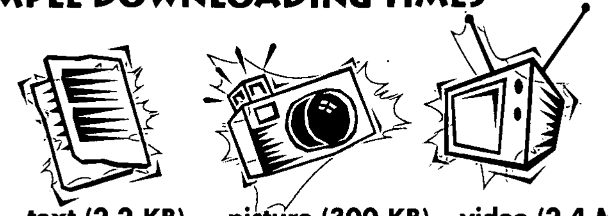
How fast is a fast modem? How will modem speed affect you and your students' work? Let's imagine that Marta and Justin both want to access a 300 kilobyte (K) image of the Orion Nebula. Modem speeds are measured in bits-per-second (bps) or thousand bits-per-second (kbps). Marta's computer has a 28.8 kbps modem and takes less than two minutes to access the image. Justin's computer has a slower, 1200 bps modem and requires a whopping forty minutes to receive the image! Clearly, modem speed can make a big difference.

Faster modems do, however, cost more than slow ones. Many teachers and other Internet enthusiasts suggest that you buy the fastest modem you can afford, saving time and money in the long run.

Another thing to consider: some Internet software is pre-configured to work with specific brands and models. Check your software before you buy a modem. If your software isn't preconfigured, select a modem for which you are sure you can get help, either from the manufacturer or the people who sold it to you. Many organizations provide technical support by phone when you have a question or a problem.

HOW LONG? HOW FAST?

SAMPLE DOWNLOADING TIMES



modem speed	text (2.2 KB)	picture (300 KB)	video (2.4 MB)
2400 bps	7.33 sec.	16.6 min.	2.42 hrs.
9600 bps	1.83 sec.	4.17 min.	33.3 min.
14,400 bps	1.22 sec.	2.78 min.	22.2 min.
28,800 bps	0.61 sec.	1.39 min.	11.1 min.

(contined from page 9)

The students were outraged. Something needed to be done *now*! Just then, unannounced visitors showed up at my classroom door. Four environmental control officers from the district had heard about our project and decided to come see for themselves what we were doing.

Personal panic time! Were we in trouble? How did they find out about the project? I wanted the students to present their findings but had always intended to go through the proper channels first.

My normally chatty class wasn't even breathing loudly. I pulled out the student graphs and presented the results of their CO_2 monitoring and health surveys. The district officers scribbled in their notepads, exchanged meaningful glances and informed us that they would monitor our classroom themselves for one week.

The kids were crushed. Why didn't the district officers believe them? I felt terrible, like I had betrayed them. Here I was encouraging them to take risks and believe that they could make a difference. What if the district officers said that their results were incorrect? I tried to remind the students that part of the scientific process is having other people replicate your work, but they weren't having any of it. Still, they didn't give up. Each day they measured CO_2 levels and compared their results with those of the district officers.

To our immense relief, the district got the very same readings that we did! The kids were ecstatic! Their work was supported and the district took immediate action—the ventilation system was fixed the next week. Students made CO_2 measurements after the workers left and announced to the school that these new levels were safe—consistently lower and well within the recommended range!

So why was all of this important? For students, it was a time of success. Adults took them seriously. They achieved what we, the faculty, had been unable to do in 17 years of complaints. They made a difference in their own lives and in the lives of their teachers and schoolmates.

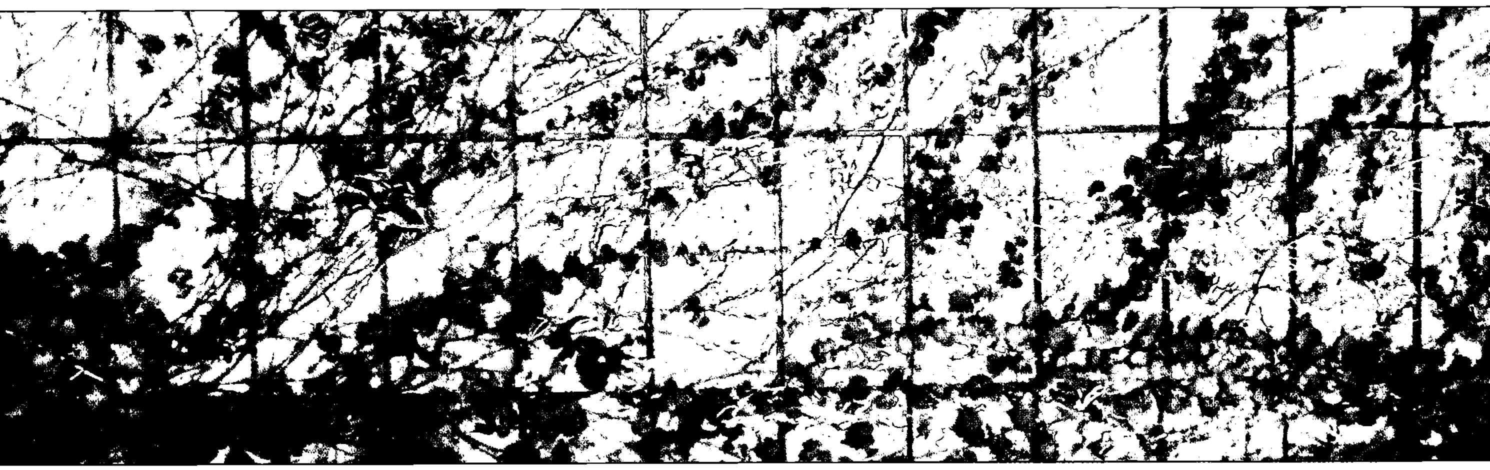
For me, the project was important because students honed their scientific, social *and* communication skills—they graphed and interpreted data; they practiced teamwork, responsibility and trust; and they discussed things with a wide variety of people. Many of them also developed new ideas about what science is. In the beginning of the project, kids would come in and ask, "Hey Miss, are we going to do Global Lab today or do we have to do science?" I consistently

informed them that Global Lab *was* science and, toward the end of the project, some of them made that connection.

The Internet played a pivotal role in all of this. My students got excited when they compared their CO_2 readings with readings emailed from other schools. I don't think they would have been as involved if they began by comparing their readings to an esoteric chart or set of standards. Communication with a worldwide peer group was crucial—it made the problem real and important.

Electronic communication also fostered changes in students' self-esteem. They ventured out into a larger world and found respect and success. They found that they could make contributions to the global scientific community. Our lack of resources didn't hold them back. They used the resources available, did excellent work and received recognition. All of this just underscores what I always knew—good things can happen anywhere!

Linda Maston and her students received the 1994 Texas Governor's Award for Environmental Excellence.



QUESTIONS & ISSUES

FINDING A GOOD FIT

Teachers and students use a wide variety of tools for teaching and learning. To explore the mathematical concept of equivalency, students might use pattern blocks or fraction kits to test theories and represent their ideas. To track local weather patterns, students might use barometers, anemometers, and other scientific instruments to take pressure and wind measurements. Each tool has uses and limitations which define the contexts and purposes for which it is best used.

What are the uses and limitations of the Internet? For what purposes is it best used and when? Each story in *Tales* shares a different way of using the Internet. What uses and limitations are demonstrated in each of the stories? What are the instructional and professional contexts and how do they translate to other situations?

WHEN WHAT YOU HAVE DOESN'T SEEM LIKE ENOUGH

The teacher and students at Pease Middle School use an outdated computer and modem. Nevertheless, they investigate air quality at their school and convince district officials to improve the ventilation system. What role does student Internet use play in this project? What proportion of student activities rely on this technology? Several teachers who read this story mentioned that it raised valuable questions about teaching with limited resources. What kinds of activities provide rich opportunities for learning but require minimal equipment and other resources? What insights can teachers develop through small-scale projects and how can this knowledge help them to articulate needs to administrators and funders?

URBAN ENVIRONMENTAL EDUCATION

Traditionally environmental education has focused on the study of natural environments such as wetlands, ponds and forests. Like Linda, many teachers and students are rethinking environmental education. What is the meaning of the term 'local environment' to teachers and students living in urban settings? What phenomena characterize that environment and how can they be reflected in science and mathematics curricula?

Many teachers opt to emphasize several different aspects of environmental education. By studying both natural and built environments, students develop deeper understandings of multiple locales. Service learning and action projects encourage students to formulate opinions and participate in decision-making processes.

PENUMBRA

GREG LOCKETT

Penumbra is a woman caught between two worlds, one of light and one of darkness. The world of light exists within the imagination and memories of Penumbra. The world of darkness is the reality around her. Together, these worlds form a shadowland where Penumbra is lost...

I paused in my reading and glanced up at Karolyn, the author. This was supposed to be a character description for a fantasy game. I suspected a more autobiographical connection. As usual, she was dressed completely in black—black pants, black shirt, and ankle-length black coat. Was Karolyn projecting her feelings onto Penumbra? Noticing my pause she asked, "What do you think?"

Karolyn was a senior in my physics class and I was very concerned about her. A recent transplant to our rural and somewhat conservative community, she withdrew more and more as the school year progressed. Her passion for fantasy and role-playing games intensified, reinforcing her alienation from other students. Usually the first student to arrive in class, she retreated into fantasy novels with an intensity that screamed *don't talk to me*. For the most part, students understood the message and avoided her.

I was also concerned about Karolyn's academic progress. Like many students, she had discovered that my physics class is very challenging. In essence, I run the classroom like a research laboratory. The students are the researchers; I am the laboratory director. My job is to make every effort to support *their* research. Initially attracted to the freedom implicit in this approach, Karolyn soon learned that conducting a scientific investigation is much more challenging than memorizing vocabulary and answering multiple-choice questions.

After a six week survey of physics and an introduction to the tools and procedures in our laboratory, it was time for Karolyn to define her first research problem. This was a very difficult task for her. She was unprepared for the intellectual independence, self-organization, and problem-solving inherent in conducting research. In addition, she was handicapped by a preoccupation with fantasy which often manifested itself as an aversion to real and logical things.

David Hershcopf, exhibiting artist and art teacher, Bentley School, Oakland, California

"Just tell me what to do, and I'll do it" was her constant refrain.

I tried to be helpful and supportive. At the same time, I was not inclined to let her off the hook. Asking questions and seeking direction is a crucial step in any scientific investigation. For Karolyn, it meant asking fundamental questions about her intellectual strengths and personal learning style, about what she knew and needed to learn. It meant creating a path from past mastery to future achievement. Although I would not define her research problem for her, I tried to help by suggesting strategies which might be useful.

"Try talking to other students who have already defined areas of interest and started their research. Perhaps you can learn from their experiences."

"Browse through our collection of student research reports. Take a couple that seem interesting and read them. Sometimes, researchers report inconclusive findings, technical problems, or promising lines for future research which might serve as a starting point for you."

"The classroom magazines also have potential," I said, pointing to issues of *The Physics Teacher*, *The Science Teacher*, and *Science News*. "One of the articles might trigger an idea that seems intriguing."

Karolyn struggled with this problem for several difficult, frustrating weeks. One day, I turned to find her clutching a copy of *Astronomy* magazine and suppressing a grin. She pointed to a paragraph describing how Edmund Halley, the noted English astronomer, claimed to ...k with elves and faeries.

REMOTE ACCESS ASTRONOMY PROJECT

Developed for high school students and teachers who want to go beyond textbook astronomy, the Remote Access Astronomy Project (RAAP) offers student access to equipment and software used by research scientists.

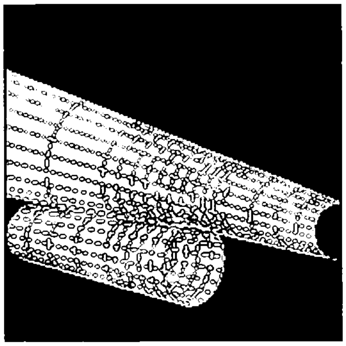
Typical classroom telescopes offer fairly low magnifications. RAAP's telescope at the University of California at Santa Barbara, on the other hand, offers much higher magnifications and records astronomical images with a sensitive digital camera. By using the Internet, students can "point" the telescope and "take a picture." The result—a digital image file—is then sent to the student via the Internet.

RAAP also provides software, manuals, and sample images through their Web site.

For more information, contact RAAP at:
raap@rot.physics.ucsb.edu
http://www.deepspace.ucsb.edu/rot.htm

ONLINE COMPUTING RESOURCES

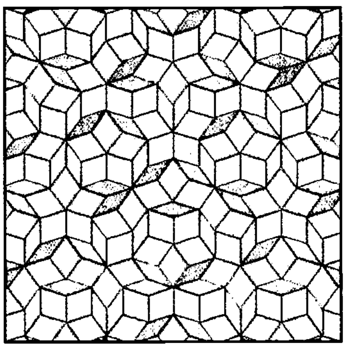
For years, scientists have used the Internet to facilitate remote access to powerful, expensive computers and software. Many similar resources are now available to K-12 students and teachers.



The **National Education Supercomputer Program** allows K-12 students to use a supercomputer to perform a variety of tasks such as generating fractals, modelling climate change and molecular movements, or conducting stress analyses of three-dimensional structures.

lindow@llnl.gov

http://nebbs.nersc.gov/



By using visualization software and a powerful computer that can be accessed at the **Gallery of Interactive Geometry**, students can explore mathematical concepts such as symmetry, pattern and periodicity.

webmaster@geom.umn.edu

http://www.geom.umn.edu/apps/gallery.html

"I can talk with elves and faeries," Karolyn said. "I want to be an astronomer."

"Any port in a storm," I thought.

"That's great!" I said. "Here's one possibility, the Remote Access Astronomy Project (see sidebar page 15). They have a powerful telescope you can use to record images of deep space objects. The telescope is about 500 miles away but you can use it via the Internet. No one one here has tried it, but maybe you could be the first?"

She looked at the cover of *Astronomy*. In her eyes, I could see dreams of creating similar images which capture the beauty and mystery of our universe.

Linda, another physics student, was sitting nearby during this conversation. As she listened, she too became enthusiastic about doing an astronomy project. They decided to form a team.

As I watched them begin their work, I wondered how this partnership would work out. Linda was very different from Karolyn. Self-confident and a star athlete, she enjoyed the respect and friendship of many of her peers. At the same time, there were obvious similarities. Both were intelligent, bookish young women who enjoyed being a little eccentric. I was guardedly optimistic.

Karolyn and Linda started with the introductory material on the Remote Access Astronomy Project (RAAP) telescope. They discovered that they needed to answer a few basic questions each time they submitted an observation request. When should the observation be made? What was the location of the object (star, galaxy, or nebula) at this time? How long should the exposure be? Thinking that the exposure time should be related to the brightness of the object, they searched for a relationship between light intensity and exposure time. When they couldn't find this information, they decided that it would make a great research question. I agreed.

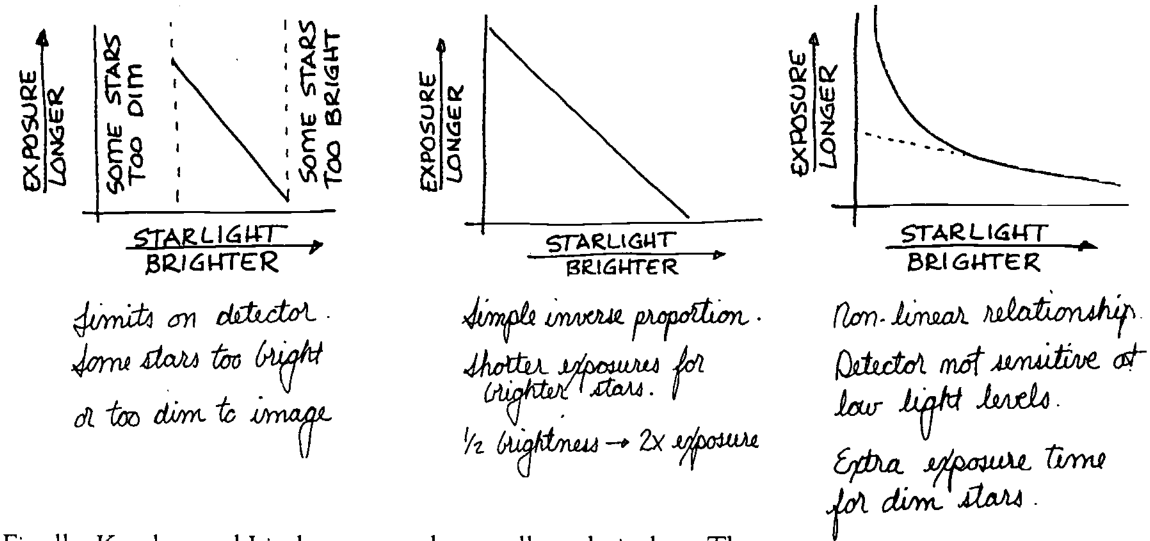
Next, Karolyn and Linda mapped out a simple strategy for answering their question. They would identify four objects in the night sky ranging from dim to bright. Then, they would use the RAAP telescope to collect several images of each object taken with different exposure times. By examining these images, they could identify the best exposure time for each level of brightness. With this data, they would create a graph which could be used to select the best exposure time for any celestial object based on its brightness.

With their research question and strategy identified, Karolyn and Linda fell into the natural work rhythm of the class. One or two days each week, they participated in short class seminars on the fundamental principles of physics, science, or research methodology. On the other days, they pursued their research.

One of their first tasks was to identify the celestial objects that would be used in their investigation. What objects were visible in the night sky at this time of year? Which ones had an appropriate

brightness? Karolyn and Linda pored over several star atlases, learning about the night sky and how it changes.

They also learned how to submit image requests to the RAAP telescope and how to retrieve the images once they were completed. I demonstrated the procedure the first time while they took careful notes. After that, they managed fairly well on their own. Using trial and error (and occasionally the instructions), they explored the system and became quite adept at navigating around and issuing commands.



Three graphs Karolyn, Linda and Greg made as they postulated how optimal exposure time might vary with object brightness.

Finally, Karolyn and Linda were ready to collect their data. They began with an image request specifying the coordinates of the Orion Nebula, part of Orion's sword and the brightest object in the test series. About a week later, they successfully downloaded their first image to our classroom. To our collective chagrin, they discovered that they could not view the file. RAAP formats its images as Flexible Image Transport System (FITS) files—a type of file format commonly used in the astronomical community—and none of the software available in our classroom was compatible. Their disappointment and frustration were obvious.

I tried to be encouraging and said, "Be happy. Big problems build strong minds."

Karolyn and Linda seemed quite undecided about my sanity. However, they forged ahead into the subject of computer file formats. Eventually with help from RAAP, we learned how to open FITS files using NIH Image, a free Macintosh program developed at the United States National Institutes for Health (see sidebar page 19). We viewed their first image, the Orion Nebula. It was uniformly gray with a smudge at the bottom and a few speckles.

"Where are all of the stars? Isn't the night sky supposed to be black? Look at the picture in this book. This can't be the Orion Nebula?" Karolyn turned to me and said, "You're happy about this, aren't you?"

I smiled and replied, "Well, strong minds build big problems." We all laughed.

This was an important moment for both students. In the past, Karolyn and Linda felt depressed and frustrated when an unforeseen event emerged in their investigation. Now, they were laughing. In my mind, both students had passed through some invisible threshold. Rather than seeing the event as an unwanted obstacle, they viewed it as just another step in the learning process.

Investigation quickly revealed that astronomical images are pretty nondescript when you first see them. They generally require enhancement and analysis before they yield their secrets. Karolyn and Linda used an inexpensive program called Macintosh Astronomical Image Analysis (MAIA) to analyze their data (see sidebar page 19). Several weeks were required to master the new software commands and associated jargon, but eventually, the team produced a satisfyingly beautiful picture of the Orion Nebula.

Displaying the first color image to the class was a proud and happy moment for Karolyn. Her interest in astronomy was motivated by a search for beauty, not truth. The knowledge that she acquired was secondary to this more basic pursuit. With a color print of the Orion Nebula in hand, her dream of capturing the beauty and mystery of our universe was first realized.

IMAGE PROCESSING

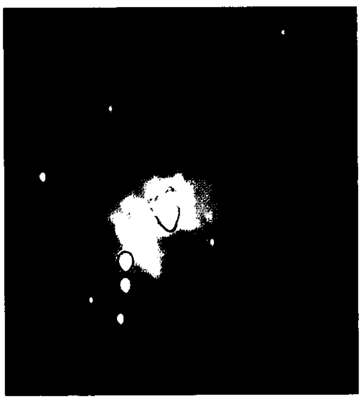
Astronomical images are beautiful *and* valuable sources of scientific data. After photographing celestial objects with a digital camera, students can edit, analyze and enhance the image to gain more information. This technique, known as image processing, helps students and other scientists distinguish details and patterns that cannot be observed by the human eye. A common research technique, image processing is used in many disciplines such as medicine, biophysics and meteorology.

For information about using image processing for math and science instruction, contact the Image Processing for Teaching Project at:

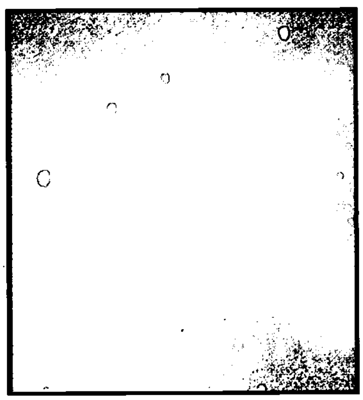
itprequest@itp.lpl.arizona.edu

http://ipt.lpl.arizona.edu/

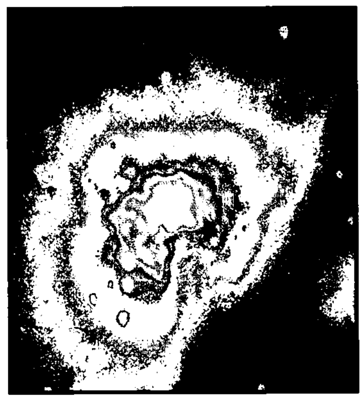
Original image of the Orion Nebula.



Slightly enhanced image shows more stars and detail about the nebula's shape.



Further processing enhances the nebula's outer edges but obscures the center.



False color accentuates differences between light intensities.

From start to finish, this research project took about five months. Karolyn and Linda, although proud of their accomplishments, were not entirely satisfied with their results. It was a stormy spring and the skies were rarely clear. This severely limited their ability to obtain images after their mastery of the process. I, on the other hand, was enthusiastic about their success. Both women learned quite a bit of astronomy and developed qualitative answers to their research question. They also wrote two papers which detailed the steps required to access, download, and process RAAP images using

the hardware and software available in our laboratory. These papers have formed a solid foundation for subsequent astronomers spending a year in residence at my laboratory.

I use a system of peer review where researchers are responsible for evaluating the work of other researchers. At the end of her project, Karolyn stood before her peers and reported on the progress she and Linda had made. She deftly fielded questions on the nuclear reactions that produce starlight, current theories on the birth and evolution of stars and the optics of reflecting telescopes. She also demonstrated significant mastery of related technological topics: the electronics associated with the sensitive detectors used by modern astronomers, image processing, and the intricacies of using telecommunications.

As I listened, I recalled the day Karolyn first expressed an interest in astronomy. Not content with merely *studying* astronomy, she had said, "I want to *be* an astronomer." I realized then that she was fulfilling that portion of her dream.

While I was very pleased with Karolyn's academic progress, I was equally pleased with her social and personal growth. In all respects, this might have been a disastrous year for her. Instead, it was a success. In retrospect, the turning point came when she and Linda formed their partnership. Each student contributed something special to their working relationship. Linda had a very practical and down-to-earth side (if it is appropriate to say this of an astronomer). Karolyn was given to sudden imaginative solutions to problems and was very adept with computers. Drawing on these complementary strengths, the two women cooperatively met and overcame repeated challenges. They also became friends. In time, Karolyn developed friendships with other physics students.

On the last day of class, I took a few moments to observe Karolyn and reflect on her progress. As she and the other students signed yearbooks, their mutual respect and approval was obvious. Not everything had changed. I could still see elements of Penumbra. She still favored black clothes; she still read fantasy novels. However, she seemed confident and connected to the people around her. Clearly, *lost* was no longer an appropriate way to describe her.

Karolyn is enrolled in our local junior college where she is taking courses which include math and science classes.

SOFTWARE

National Institutes for Health Image (NIH Image) and Macintosh Astronomical Image Analysis (MAIA), the two image processing programs Karolyn and Linda used in their astronomy project, are available via the Internet.

NIH Image is public domain software and is therefore free.

http://rsb.info.nih.gov/nih-image/

MAIA is shareware—users can access it at no charge but are asked to pay a $20 registration fee.

http://www.deepspace.ucsb.edu/util/

QUESTIONS & ISSUES

PROJECT-BASED SCIENCE

Greg has developed an unusual learning environment, one that offers challenges to Karolyn and, presumably, to other students. What issues do teachers face when they implement a more project-based approach? For some teachers, the big question is design. How should the curriculum be structured to slowly introduce students to different tasks and ways of learning? What kind of project framework allows students flexibility and choice while giving them the support and guidance they need? For other teachers, the ongoing issue is student learning. What do students get out of project-based science that they can't get in a more traditional environment?

LabNet, a community of high-school teachers who teach project-based science, offers a wonderful resource for teachers who are using or would like to explore this approach. Entitled *LabNet: Toward a Community of Practice*, the book shares the struggles and successes, lessons learned and ongoing issues of teachers and project staff.

LabNet: Toward a Community of Practice. Richard Ruopp, editor. Lawrence Erlbaum Associates, 1993. $34.50. 800-926-6579.

FORMING TEACHER COMMUNITIES

Several teachers who reviewed drafts of this story mentioned that it was simultaneously inspirational and intimidating. How did Greg develop his knowledge of science content and teaching? How did he acquire and learn to use all that equipment?

Part of the answer is simply time and experience. Greg has been a teacher for over twenty years. Currently working with high school students, he has also taught elementary and middle school and worked as a research scientist.

Greg also benefits from strong connections he has established with local and national communities of teachers. His partnership with Scott Battaion, another science teacher at Cottonwood High School, has provided opportunities for ongoing discussion and team teaching. Talking with other technology-using teachers in the district helps him to keep abreast of current innovations and implement long term, coordinated plans for funding and acquiring equipment. In addition, Greg is a long-standing participant in LabNet, the community of high school teachers mentioned above.

Starting Simply

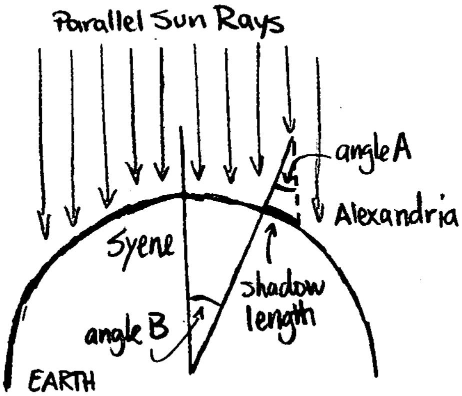
TALL SHADOWS

KAREN NISHIMOTO

ERATOSTHENES'S EXPERIMENT

Long before Europeans realized that the Earth is round, Eratosthenes—a scholar living in Alexandria approximately 200 years before the birth of Christ—performed an experiment and concluded that this was the case.

Eratosthenes compared summer solstice observations made in Syene, a southern city near the Nile River, with the observations he had made in Alexandria. In Syene, shadows cast by vertical sticks became shorter and shorter as the morning progressed. At noon, they disappeared and the sun could be seen directly overhead. In Alexandria, something very different occurred—shadows became shorter but did not disappear.



Eratosthenes reasoned that this difference happened because the Earth is round and has a circumference of approximately 25,000 miles.

For more information about Eratosthenes and his experiment:

Cosmos. Carl Sagan.
Ballantine Publications, 1985, $5.99.
800-733-3000.

"What do you mean you don't know? How can you expect us to solve a problem if you don't know the answer?" Michael's troubled expression said it all. Like many of my students, he prefers to work on problems that someone knows how to solve—science projects that follow prescribed procedures and yield predictable results.

Michael is one of the 135 seventh graders I teach at Punahou School in Honolulu, Hawaii. Our science curriculum covers physical, Earth and space science. We do quite a few laboratories: some are "cookbook" laboratories, others are more open-ended. The annual science project is our most open-ended activity. Announcing it to the class and encouraging them to work on questions without known solutions, I could sense their anxiety. Michael was not the only one feeling uncomfortable.

Within a month, most of the students had identified problems. Michael chose to do a safe project comparing the acidity and sugar content of colas. Melanie, Alex, Elise and Kawika, on the other hand, chose something a little riskier.

"Mrs. Nish, we're planning to do something like Eratosthenes's experiment. You know, like in the video."

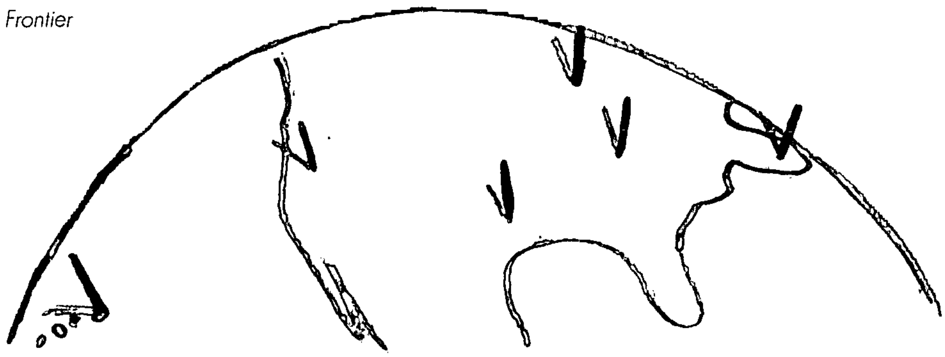
"Sounds good. How are you planning to approach the problem? Don't forget, your first hypothesis is due by the end of the month."

"No problem! Eratosthenes did his experiment on the summer solstice. We can't wait until June 21 so we'll start collecting data next month. This means our experiment will be different from Eratosthenes's, but we'll be done by Christmas break. We'll use email to explain the data collection procedure to students at other schools and then they can email the shadow measurements back to us."

Now I was the one feeling nervous. None of us were Internet experts. I had been using email for four months; most of the students had been using it for one. What if something went wrong? I didn't want students spending all their time troubleshooting technological glitches.

I was also concerned with how telecommunications would fit with what we currently do. I want my students to learn how to think scientifically and to conduct scientific investigations. How would using email help them to learn and carry out these processes?

The four students began by doing a dry run of the experiment. They began to visualize the problem—it wasn't as simple as they had thought. Many of the conditions that made Eratosthenes's experiment so easy to solve were different in their experiment. As Melanie noted, collecting data in the winter meant that the sun would not be directly overhead any of the schools. Also, none of the other seven schools were directly north or south of us, so all the shadows "pointed" in different directions.

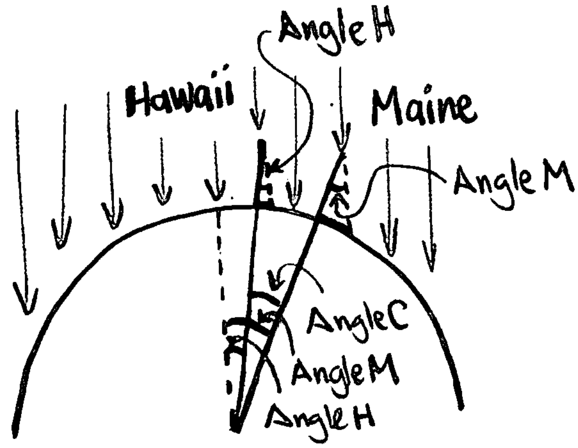


Our one classroom computer, a Macintosh SE with a tiny black and white screen, became a rallying point during class breaks as the Punahou students, a.k.a. the Urchins, communicated with students at other schools. After designing the experiment, the Urchins enlisted data collection teams at the eight participating schools. In all, over seventy students participated in the project. As the emails poured in, the Urchins found themselves in a new role: clarifying procedures, explaining the importance of each variable, and generally serving as the glue that held everything together. Soon the Urchins were faced with their next challenge: interpreting the data.

What is the distance between our school (Hawaii) and the school in Maine?

C = M − H
= 83° − 63°
= 20°

20° is 5.5% of 360°
so the distance between our schools is 5.5% of the Earth's circumference. (2224 km)



Their first hypothesis used the difference between shadow angles to calculate the distance between schools. The fact that their shadows, unlike Eratosthenes's, pointed in radically different directions was conveniently ignored. Still, the Urchins were excited and had worked hard on their solution.

Spurred by the success of their discussions with other students, they emailed their hypothesis to Dr. Arno Penzias, Nobel Prize winner and head of research at Bell Laboratories. Anxious to hear from him, they haunted the computer waiting for his reply.

> I don't think that your method works unless the Sun lies in a plane directly defined by 3 points: the two points at which you are making measurements and the center of the Earth.

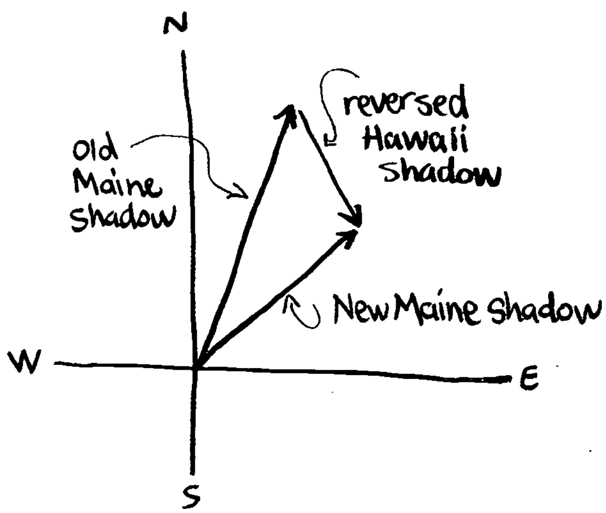
Suppose, for example, the Sun was directly above the equator, and your two points of measurement were both up near the North Pole. Would that give you the right answer? Keep thinking and look at a globe, not a flat piece of paper.

Good luck, Arno Penzias

Wow—a Nobel Laureate had looked at their hypothesis, treated them as fellow scientists and made suggestions. The students nearly ran the ImageWriter dry as they printed his email and shared it with their friends. It didn't seem to matter that his suggestion was to try a different approach.

Soon enough reality set in and it did begin to matter. Dr. Penzias suggested that they look at a globe, so Elise found one and the Urchins started brainstorming. Periodically checking in on their discussions, I realized they were having difficulty visualizing the problem and suggested modelling clay. Alex took up the idea and also decided to use a flashlight to represent the Sun. Within minutes they were using their model and working out a new hypothesis. As it turned out, the flashlight was a weak substitute for the Sun and generated diffuse shadows that were difficult to measure. Kawika suggested the overhead projector and soon its bright light was on, blasting everyone in the eyes but producing clear, sharp shadows.

As they moved the globe and overhead around, the Urchins started to get a feel for how relative position of the Earth and Sun caused the shadows to change. Their first task was to identify the Earth/Sun placement that best reproduced their data. Curious to compare their experiment with Eratosthenes's, they placed the Sun directly above the Hawaii site and measured the shadows that resulted at other school sites. How did this new data set relate to their old data set, the one they had collected with the other students? Could these measurements help them in their original task: calculating the distance between schools?



The old and new data are related.

- draw the old Maine shadow
- now draw a reversed Hawaii shadow at the end of the old Maine shadow
- connecting the origin to the end of the reversed Hawaii shadow gives another shadow: one that agrees with the new Maine data!

(continued page 28)

Choosing a Service Provider

Choosing an Internet service provider—the organization that provides your Internet connection—can be a complex task. Where do you start? What questions should you ask? How do you estimate cost? This article provides an overview of Internet service providers and offers suggestions and criteria to help you find a good fit. It also includes phone numbers for a select group of major providers.

Know Your Needs

Step number one to finding the right provider is knowing what you need. What Internet services will you and your students use: email, newsgroups, Gopher and/or World Wide Web? What computer system will you use and where is it located? How much time will you be spending online and when will it occur: morning, afternoon or evening? The answers to these questions will help you to better know your needs, estimate costs for different providers and ultimately choose one that is a good fit.

Strategies for Success

Sometimes the smartest thing to do is ask for help. Who are the technology-savvy teachers at your school? Who are the technology specialists in your district? There's nothing better than getting one-on-one help and experience. Don't forget friends, students and their parents—consider all the people in your personal and professional life as you identify individuals to ask for support.

Books can also help you make sense of the process and develop well-informed decisions. *Connecting to the Internet* by Susan Estrada is an in-depth but concise reference for new or experienced users. Published by O'Reilly and Associates and available for $15.95 (800-998-9938), it includes chapters on defining your needs, comparing services, and estimating costs.

Local Solutions

As you talk to the teachers and specialists around you, ask how they are connecting to the Internet. Do they work with a local college or university? Are they connected through a nearby government agency or research institution? These organizations were among the first to use the Internet and sometimes provide Internet service to local teachers and students.

Many states (and some commercial providers) offer inexpensive or free Internet service for educational use. These Internet service providers can be a wonderful place for teachers and students to get started. Designed specifically for the K-12 audience, these providers are cognizant of the realities of school life and offer access to existing communities of teachers and students already online.

Access to Internet services and ease of use vary widely from state to state and from university to university. As you gather information about the types of providers described above, it's important to get lots of details. What kind of software will you need to connect to their system? Many state and university service providers use a type of software known as terminal emulation. Although this software runs on almost any type of computer (even an Apple II!), it can be difficult to learn and use and cannot display pictures. You should also ask what services and technical support they provide and how accessible those services are.

Pros

✓inexpensive or free Internet service

✓Internet access is a local phone call

✓software that can be used on almost any computer

Cons

✓software that is difficult to learn and use

✓no pictures, only words

A Focus on Information

Many teachers choose to access the Internet through commercial providers such as America OnLine, CompuServe and Prodigy. These Internet service providers offer easy access to online information, much of which is specific to their service. They also offer strong technical support, both online and by phone and fax.

The majority of these providers develop their own easy to use and install software and distribute it to users for free. America OnLine (AOL), for example, has its own AOL software which people must use to access AOL service. This kind of software is more sophisticated than terminal emulation software. Often referred to as a graphical user interface, it allows users to point and click and to display pictures as well as words.

There are disadvantages, however, to working with this type of Internet service provider. Their software, although easy to use and install, is often incompatible with other Internet software. Much of the scientific visualization software developed for use over the Internet, for example, is not compatible with software developed by commercial providers. In addition, their pricing structure emphasizes low costs for low usage and increases rapidly with heavy usage. This aspect can become a problem for teachers and students using this type of service in classroom situations.

For many teachers, working with a commercial Internet service provider is a stepping stone—a place to begin and get acclimated. After taking advantage of an introductory month of free service, they have a clearer sense of their needs and sometimes switch to other Internet service providers.

Pros

✓low cost for low usage

✓pictures and words

✓good technical support

Cons

✓high cost for heavy usage

✓less software flexibility

Contact Information for Select Providers

America Online: 800-827-6364

CompuServe: 800-848-8199

Prodigy: 800-776-3449

A FOCUS ON SOFTWARE FLEXIBILITY

Many commercial providers offer Internet connections known as Point to Point Protocol (PPP) or Serial Line Interface Protocol (SLIP). These connections can be used with many different kinds of software and allow users more choice and flexibility.

PPP and SLIP connections allow users to have full Internet access—the ability to use all Internet software and access all Internet resources—but require only standard equipment (a computer, modem and phone line). Teachers who use these types of connections also develop knowledge and experience that can be very valuable in other situations, such as helping to install and troubleshoot a schoolwide Internet connection.

Some of these providers offer excellent technical support and easy-to-install software. Others do not. Be sure to ask what technical support each provider offers and choose the one that offers the best options. Good support is particularly important in the beginning, when you install software and establish a connection.

Basic rates for SLIP and PPP connections may seem a little higher than other types of connections. These connections, however, can be cost-effective for users who require substantial online time. This can be particularly important for teachers and students using the Internet for instruction.

Pros

✓many software choices

✓provides valuable experience and knowledge

✓low cost for high usage

Cons

✓software can be difficult to install without support

✓high cost for low usage

COMPARING COSTS

Cost is a major issue for anyone choosing an Internet service provider. How do you know how much your Internet connection will cost? What questions should you ask each provider to get the information you need?

The chart on the right will help you to compare provider costs. Begin with an estimate of how much time you will spend online per month. Then contact different providers, ask questions and fill in each column of the chart. Do they charge new users an introductory setup fee? What is their fixed monthly charge? How many hours does it include?

Take your time and be careful not to jump to conclusions. Providers that offer low monthly charges may offer few hours of service and high extra charges. Do your research and determine the real costs for different providers—it will be well worth your while.

Service Provider	Setup Fee	Fixed Monthly Charge	Hours Included	Extra Hourly Charge	Other Costs	Toll Charge Incurred	Estimated Monthly Cost
1							
2							
3							
4							
5							

How much time will you spend online per month? ________

Contact Information for Select Providers

MCI: 800-955-5210

Netcom: 800-353-6600

Performance Systems International (PSI): 800-774-0852

THE INTERNETWORKED SCHOOL

Ideally, all schools would have internetworked computers—computers that are connected to each other and to the Internet. As we know, that is often not the case. Too many schools have only a few computers, many of which are old or unused.

The important thing is to remember that this option exists and to think opportunistically. Develop your own knowledge and experience in ways that will help you to contribute to planning and implementing a school network. Think through each new funding opportunity and consider how a school network and Internet connection might contribute to that effort. If you think there might be educational benefits, include costs for equipment, installation, and professional development in the grant.

Pros

✓full Internet access

✓easy to customize

Cons

✓significant startup cost

✓introduces schoolwide need for technical support and professional development

For more information about planning a school network:

Building the Future—K-12 Network Technology Planning Guide, California Department of Education
http://goldmine.cde.ca.gov

Smart School Technical Guidelines for Schools
http://www.svi.org/guidelines.html

LEARNING CIRCLES

Originally developed through the AT&T Learning Network, Learning Circles are now hosted by the International Education and Resource Network (I*EARN).

Each Learning Circle consists of eight to ten geographically dispersed classes with a common educational focus. Teachers and students work collaboratively to develop and implement projects over a 14 week period. Each class takes the lead on one project and helps carry out projects sponsored by other classes. Students then summarize their work in a publication and share it with the entire Learning Circle community.

The idea is to develop an environment in which teachers and students can learn from one another. Participating classes also receive support from Learning Circle staff and curricular resources.

For more information, contact Learning Circles at:

mriel@iearn.org

http://www.iearn.org/iearn/circles/lc-home.html

(continued from page 25)

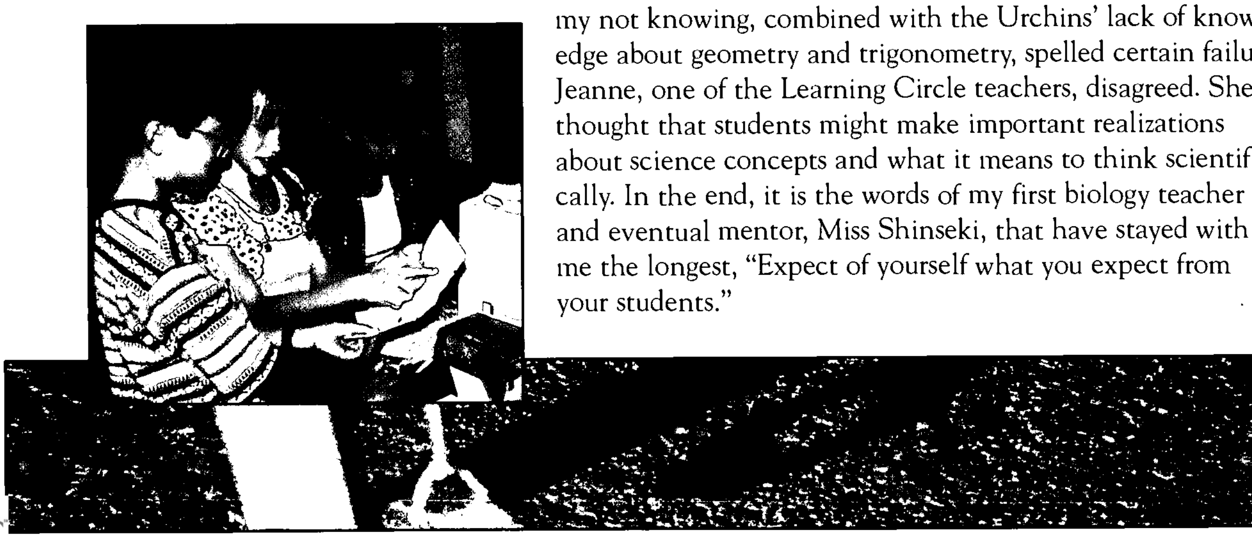
Trying to answer this question, Elise began plotting the old and new data on graph paper. Kawika and Alex suggested that she draw a "reversed Hawaii shadow" to illustrate how their shadows might change and diminish over time. It was then that Melanie noticed a mathematical relationship between the old and new data.

Was this a coincidence? Would this relationship help them calculate the distance between school sites? The air was electric as they used their new method and compared the calculated and known distances. Triumphant screams broke out as the numbers came in. Most of the calculated distances were off by less than five percent. Only one, the distance between our school and Tillicum School in Seattle, seemed way off. The Urchins noticed that Tillicum was our nearest participating school and began a new set of calculations, trying to determine when their approach would not work and why.

The Urchins continue to hone their hypothesis and to email Dr. Penzias. Working with their three-dimensional model, they reformulate their old hypothesis and explore new approaches. I grapple with their questions and many others.

Why do Michael and the Urchins feel differently about tackling open-ended problems? Michael's project, like much of his work, was excellent. Still, I felt a little disappointed that he did not choose a truly open-ended project. What if he had worked with the Urchins? What would they have learned from one another? I consciously foster student inquiry throughout the science program but sometimes students just aren't ready to make that jump. What can I do to help my Michaels risk uncertainty?

I also question if it matters when I don't know the answer. When the Urchins first outlined their project, I was not sure how to approach the problem and did not know if it could be solved. My question sparked vigorous discussion with my Punahou colleagues and the Learning Circle teachers (see sidebar this page). Several teachers suggested that my not knowing, combined with the Urchins' lack of knowledge about geometry and trigonometry, spelled certain failure. Jeanne, one of the Learning Circle teachers, disagreed. She thought that students might make important realizations about science concepts and what it means to think scientifically. In the end, it is the words of my first biology teacher and eventual mentor, Miss Shinseki, that have stayed with me the longest, "Expect of yourself what you expect from your students."



Questions & Issues

Working with Subject-Matter Experts

Professional scientists and mathematicians such as Dr. Penzias can offer a wealth of information and technical support to students and teachers. As Karen's story points out, conversations between students and subject-matter experts, which helped to focus student projects, can validate and further motivate student work.

At the same time, it's important to consider what skills and expertise subject-matter experts typically do and do not have. How can teachers help scientists and mathematicians become better observers of student thinking? How can they help them facilitate conversations and use effective questioning strategies?

Student Views of Learning

Several teachers who read drafts of this story mentioned that they often encounter students like Michael and the Urchins in their own classes. What kinds of events and individuals shape student attitudes toward risk taking? How do students develop their ideas about the role of risk taking in learning? How can it be encouraged?

Beliefs About Teaching

Toward the end of her story, Karen describes conversations with other teachers in which they talk about the Urchins' shadow measurement project. Some teachers suggest that the project is inappropriate for seventh graders because they don't have formal understandings of geometry and trigonometry. Other teachers take a more constructivist approach and suggest that this is a fine way to introduce students to new concepts.

What assumptions are at the heart of these different approaches? How might these different ways of teaching shape the way students view scientific endeavor?

PEDAGOGICALLY SPEAKING

BILL BARNES

My fourth graders teach me how to be a good teacher through their comments and behavior. Sometimes, they get off-task because I assign math problems that are too easy. In other situations, they become frustrated and despondent because the problems are too hard.

I also learn things from other teachers. Talking about new ideas and strategies can be helpful but it takes time, something I never seem to have enough of. How does one learn from others and still manage to have a life?

In the fall of 1994, I enrolled in Cooperative Learning in Mathematics, a class for teachers that "met" via the Internet. Advertised as "professional development that would fit into your busy schedule and provide opportunities to learn from other teachers' experiences," the class was part of a series called the Math Learning Forums (see sidebar this page). I was intrigued and soon found myself part of a ten-person cyberspace classroom. All of the class participants were teachers who taught math to children in grades five through eight (I taught fourth grade but decided to enroll anyway). The facilitator, Maya, was a professor at Bank Street College in New York City. All of us had email and communicated through an electronic mailing list (see sidebar page 32).

I had been using groupwork in my math classes for quite some time but still had questions. When do other teachers use groups of two? When do they use groups of four? I find that it's hard to keep students engaged in large groups and I typically group students in twos and threes.

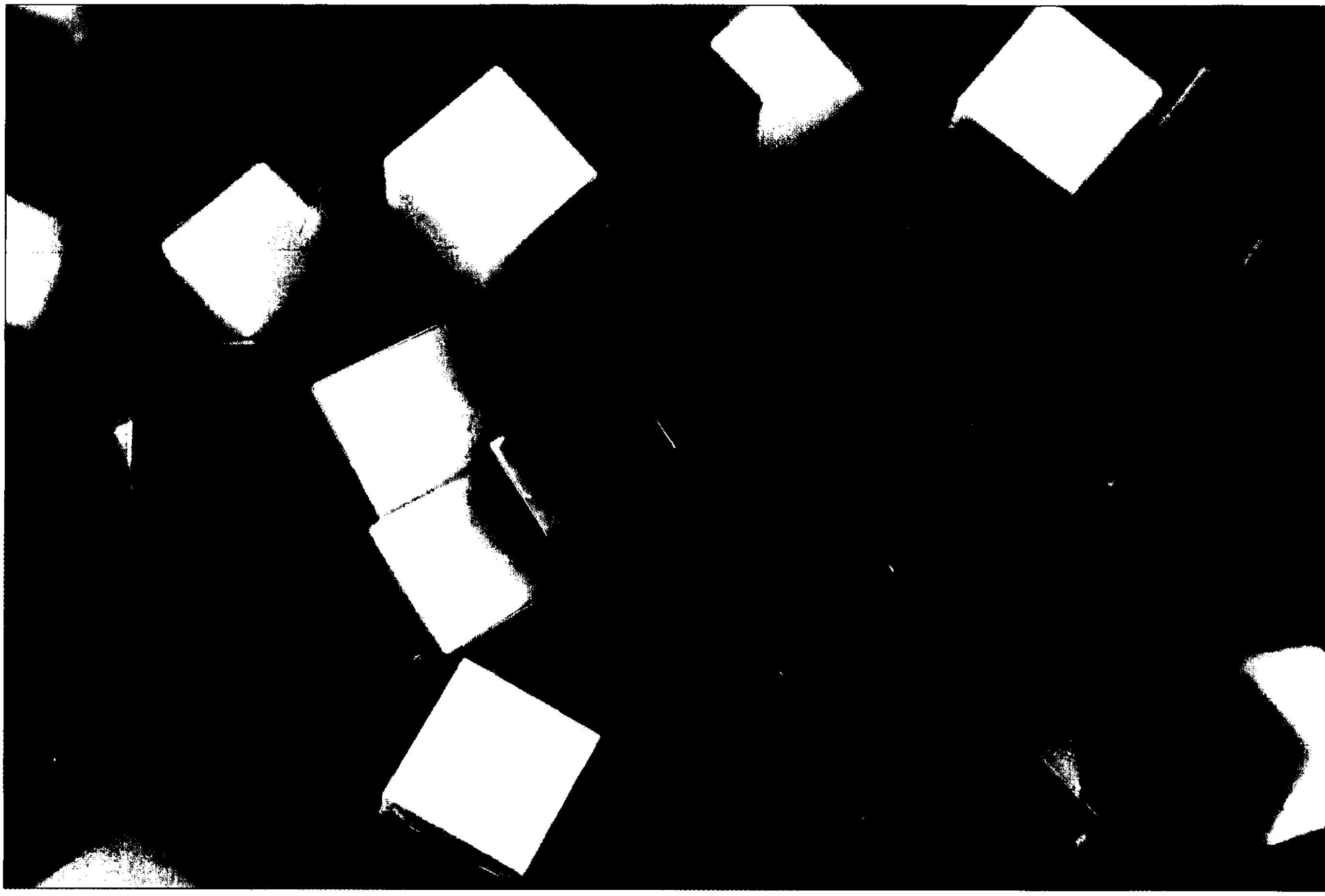
MATH LEARNING FORUMS

Mathematics Learning Forums are designed to help teachers introduce new mathematics teaching practices in their classrooms in accordance with current nationwide mathematics reform efforts.

Each forum is facilitated by a Bank Street College faculty facilitator and focuses on a particular area of instruction: mathematics content, student learning, teaching strategies or assessment techniques. Participants examine their own and other classrooms by viewing videotapes, conducting activities with their students and talking with others through an electronic mailing list.

Mathematics Learning Forums are eight weeks long and include up to twelve participants. Course costs vary with the type of credit given. Forum participants must have email access and should expect to spend a minimum of three hours per week contributing to and shaping online conversation.

For more information, contact the Math Learning Forums at:
nross@confer.edc.org
http://www.edc.org/CCT/mlf/MLF.html



I was also interested in the issue of roles. How do other teachers ensure that everyone contributes? How do they keep some students from dominating a group's process? As the forum began, I felt excited thinking that I had questions to ask and insights to share.

The first big assignment was an activity called Cube-It.

What are the dimensions of the largest cube you can make with 50 cubes?

Our task was to do the activity with students and participate in an ongoing discussion, both before and after teaching it. Maya suggested that we start by doing the activity ourselves and by sharing our initial thoughts. How would we begin the activity with students? What were our expectations: mathematical and behavioral?

Most of the teachers planned to use cooperative groups of four. Much to my delight, Margaret—a fifth grade teacher from Portland—immediately brought up the issue of student roles.

> **I want to add my voice to those who have found that the commonly assigned specific roles for cooperative learning activities (counter, recorder, reporter, facilitator) need to be designed as carefully as the activities themselves. It works**

LISTS

Electronic mailing lists—also known as lists or listservs—make it easy for large groups of people to communicate with one another. Imagine that you are one of 50 teachers in your state working on a new math curriculum framework. How can you efficiently hold online group conversations without having to type in all 50 email addresses each time you send a message? Using a list allows you to type in one email address (the list address) and send your message to everyone.

The requirements for participating in a list discussion are relatively few. You need to have email and information about your list. What is the email address of the list? How do you begin participating, a process also known as subscribing? Here are two lists and instructions to help you get started.

Hosted by the National Council of Teachers of Mathematics (NCTM), **NCTM-L** focuses on teacher issues and concerns about implementing the NCTM Standards.

- send email to **majordomo@forum.swarthmore.edu**
- type **subscribe nctm-l <your full name>** in the body

KIDPROJ was designed to enable teachers and youth group leaders to provide projects for children ages 10 through 15 via the KIDLINK network.

- send email to **listserv@vm1.nodak.edu**
- type **subscribe kidproj <your full name>** in the body

> **best for me when they are tailored to the activity in a way that makes sense (at least to me). The roles need to be integral to the success of the task. If a group doesn't seem to need a checker to accomplish the task, I don't assign that role.**

Margaret's comments pushed me to reevaluate past fiascos where I had grouped students in fours and fives. What tasks had I assigned in those lessons? How did those tasks accommodate (or not accommodate) different roles for different students?

Margaret also suggested that there might be times when "more learning accrues if no roles are assigned." For the Cube-It problem, she was going to assign students to groups randomly and have her fifth graders define and assign roles themselves. On the other hand, Anand, a sixth grade teacher from St. Louis, planned to group his students heterogeneously according to ability and to assign specific roles.

Having consistently crashed and burned with large groups, I listened carefully to their approaches and made a mental note to pay special attention when they reported back to the group after their students did the activity.

As I pondered my original questions about grouping, I found myself also thinking about the mathematics. What did I want students to learn? What did they know already that would pertain to the Cube-It question? As I thought through these issues I realized that my fourth graders would need time to explore patterns and perhaps even construct their own definition of a cube.

I decided to change the activity and planned a series of tasks to build up to the Cube-It question. Students could work in teams of two and use centimeter cubes to build boxes. How many different boxes can you build with one cube? Two cubes? Ten cubes? Each pair could build boxes and record the dimensions and volume (number of unit cubes required). As they worked, we could talk about the different patterns they found. Then I would ask them the Cube-It question.

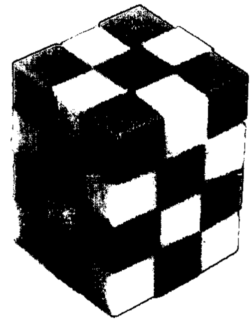
The actual lesson went well. Hannah and Elise discovered a pattern and shared it with me and with Wes and Brandon, the team closest to them.

"These boxes," Hannah said, pointing to a 1x1x2 box and a 1x1x5 box, "are one-of-a-kinds. They are the only box that can be made with that many units."

Further exploration revealed that if you start with a prime number of units, the only complete boxes you can make are long and skinny.

Many of the students also informed me that there were "special boxes," boxes for which the length, width and height were equal. Some students began calling them cubes, others did not. All the students recorded that the 2x2x2 special box required 8 units, that the 3x3x3 box required 27 and that the 4x4x4 box required a whopping 64 units. Later, when I asked what the largest special box (cube) was

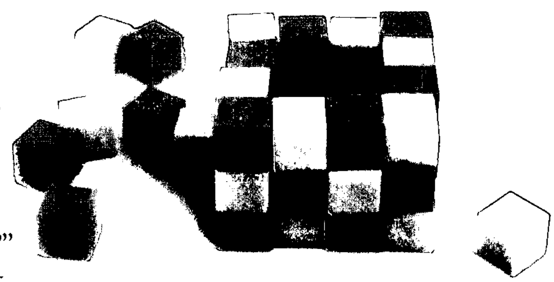
that could be built with 50 units, hands shot up all over. Everyone recognized that the 3x3x3 cube was the largest and that there would be units left over.



Other forum participants had completed the Cube-It activity with their students and began to describe their experiences and share their thoughts. Anand and Margaret, two teachers who had grouped their students in groups of four and five reported that "things went great" and that "students answered each others' questions and developed multiple approaches to the problem." James, on the other hand, reported that "groups of four were too large" and that "some students did not have anything to do." His suggestion was to group students in twos and then have pairs gather in groups of four to compare results.

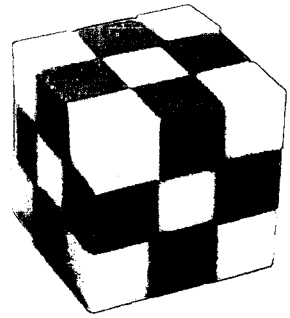
Teachers also began talking more about the mathematics. As Alan noted,

> **Students were surprisingly stymied by the concept of a cube. They also had difficulty understanding that the number of units could be determined by raising the length of a side to the power of three. Once they did make that connection, however, they were off and running.**



James's comments were echoed by several other teachers. Joyce's fifth graders felt unsure of what exactly a cube was and began by constructing long chains. Margaret's fifth graders needed time to develop their own working definition of a cube. Were cubes "the same all around?" Were they hollow or "all filled in in the middle?" Although Sandra's seventh graders quickly made cubes of different sizes, they were surprised to discover that the number of units required could be predicted by cubing the length of one side.

Over the course of one or two weeks all 12 teachers described how the Cube-It activity went in their classroom. Rereading their email messages as a group, I struggled to synthesize them and distill a few truths to take away about cooperative learning. It wasn't easy. Some teachers reported that the task worked wonderfully with large groups of students, others suggested that groups of two were more appropriate.



A few things did emerge, however. Student preparation was clearly a key factor. Students who regularly did cooperative classwork performed well in small *and* large groups. Students who were less familiar or were being introduced to cooperative work during the Cube-It lesson experienced more difficulty. Going back to prior lessons, I tried to remember how many times I had assigned students to large groups. Had we tried groups of four several times in a row? What had I done to foster cooperative work among large groups and how long did I persist? It had seemed like a long time but now I wasn't sure. Perhaps I needed to try using larger cooperative groups again.

The emphasis on group discussion and reflection was one of the things I most appreciated about the forum. Because we were communicating by email, I could take my time and think about what each person was saying. What was the reasoning behind their choices and actions? How might their approaches and strategies apply to my situation? When I take traditional classes at the local university, I am always rushing around trying to get to class on time and to then come home and prepare for the next day of teaching. The forum gave me more latitude in terms of when I participated and allowed me to think more deeply about other teachers' experiences as well as my own.

I also appreciated the fact that the forum was a teacher-to-teacher conversation about real classroom events. Although we read and discussed research-based articles and books, the discussion seemed concrete and grounded in real practice. Teachers shared tips, resources, and strategies. Maya, the faculty facilitator, guided the discussion and participated as a peer.

I don't mean to say that the forum was perfect. There were technical problems (the forum I participated in was a pilot and therefore much rockier than current forums). I often wanted the discussions to be fuller and to explore the mathematical and behavioral issues more deeply. I wish, for example, that we dealt with the ways in which cooperative work influences student views of mathematics. Other questions were also posed that were never addressed. Still, I suspect that these problems are not specific to the forum or to online discussion.

For me, the trick is to figure out how to engage in dialogue that generates better teaching and renewed professional enthusiasm. I think that the Internet, although only part of the solution, presents a real opportunity for teachers to learn from and inspire each other.

COOPERATIVE LEARNING

Readings from Educational Leadership: Cooperative Learning and the Collaborative School. Ronald Brandt, Editor. Association for Supervision and Curriculum Development (ASCD), 1991. $21.95. 703-549-9110.

A compilation of practical and easy-to-read articles originally published in *Education Leadership*, this book focuses on cooperative learning and collaborative schools.

Cooperative Learning in Mathematics: A Handbook for Teachers. Neil Davidson, Editor. Addison-Wesley, 1990. $24.95. 800-447-2226.

Davidson's book touches on issues specific to incorporating cooperative learning into mathematics instruction: structuring math-related cooperative groupwork, designing appropriate tasks, and other issues.

Designing Groupwork Methods: Strategies for the Heterogeneous Classroom. Elizabeth G. Cohen. Teachers College Press, 1994. $17.95. 800-575-6566.

A wonderful introduction to cooperative learning in the heterogeneous classroom, this book shares practical strategies, classroom vignettes and research findings.

QUESTIONS & ISSUES

NATURE OF THE DISCUSSION

The conversations that took place during the Cube-It activity illustrate teacher learning that both draws on and informs classroom practice. Bill and the other forum participants raised a number of practical and theoretical concerns during the Cube-It discussion. How did the structure of the forum generate and inhibit discussion? How were issues discussed and who answered the questions that were raised?

In the Cube-It activity, forum participants began by sharing expectations, both mathematical and behavioral. Next, they conducted the activity with students and described the experience to other teachers in the forum. What issues came up during these discussions? How would it have been different if teachers talked about these issues "cold," without going through a common activity? What if their discussion had been based on an article or book?

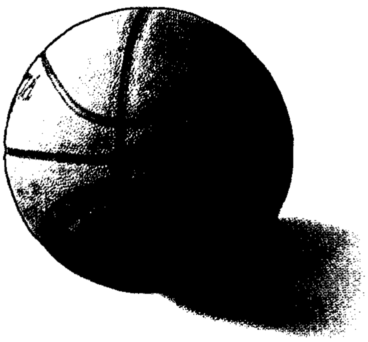
BUT WHAT DID MAYA DO?

This story makes little mention of Maya, the professor at Bank Street College who facilitated the forum. In fact, one teacher who read this story was unsure what part she played in forum discussions. Before the forum began, Maya played a very active role. She and other Bank Street faculty planned the syllabus and chose the activites. Once the forum began, however, her focus shifted to guiding the conversation and encouraging others to speak.

Some electronic mailing lists include a facilitator like Maya. Others do not. How might teacher-to-teacher discussions differ in facilitated and unfacilitated lists? What are the advantages and disadvantages of each?

HOOP HAPPENINGS

CAROLINE BRENNAN
JOANNA YANTOSH



My sister Caroline and I both teach at Drexel Hill School of the Holy Child, an independent Catholic school near Philadelphia serving approximately 225 girls and boys in grades pre-kindergarten through eight. Like many of the school faculty, we teach several subjects. The majority of our classes are fourth through eighth grade math; we also teach reading and social studies.

We are quite close, even for sisters, and talk about everything: how our lessons go, what progress individual students are making, and ways to improve student learning. We also share a strong interest in implementing standards advocated by the National Council of Teachers of Mathematics, particularly the standard that focuses on "mathematics as communication." How can we encourage students to talk and write about mathematics? How can we help them to use different forms of communication to deepen their understanding?

Exploring these questions through new activities and teaching strategies led us to collaborate with an instructor and college students at Iowa State University. The Mathematics and Communication Project (see sidebar page 37) pairs Iowa State students with groups of children at Holy Child. The college students, mostly seniors majoring in education, participate through their elementary math teaching methods class. Once a week, each of them sends a math problem to his or her group of elementary students, then helps them to grapple with it. The children work cooperatively in groups of three or four to solve the problem and explain their answer. All of the discussions take place via email.

When the project began, Caroline and I were unsure how things would work out. It was our first time using the Internet with children and we had never collaborated so closely with college students and teachers. Dawn, the Iowa State instructor, was hoping the college students would gain insight into children's thinking about mathematics, supplementing their student teaching experience in nearby Iowa schools. Caroline and I saw this kind of long distance exchange as an opportunity for Holy Child students to talk and write about mathematics in a new way. Would their use of the Internet foster mathematical communication? Would it deepen their understanding?

The "Big Eight Basketball Problem" was the fourth problem Maddie sent to Keisha, Samuel, Megan and Dominic, a group of fourth graders who call themselves the Math Maniacs.

"Maddie sent us an easy problem this week," Keisha said, shifting the group's log book so I could see.

Big Eight Basketball Problem:

There are eight basketball teams in the Big Eight Conference, INCLUDING Iowa State University. If each team plays each of the other teams twice during the season, how many total games must be scheduled?

My initial response was concern. Are fourth graders ready for this kind of logic problem? Normally if Iowa State students assign a problem that's beyond the children's reach, we send it back and ask for a new one. This time I decided not to intervene. The Maniacs had the basic skills necessary to solve the problem, and they seemed ager to tackle a new challenge. Besides, both Maddie and I were vailable to help when asked.

MATHEMATICS AS COMMUNICATION PROJECT

Iowa State University students learning to be teachers work with student groups at several elementary schools throughout the United States. Each week, these preservice teachers send nonroutine math problems to their student groups and help them to solve the problem. Communication occurs via email. Many children and college students choose to exchange pictures, making the interaction more personal.

For preservice teachers, the activity is about developing their own mathematical problem solving skills and becoming better prepared facilitators of student learning. It also provides them with an introduction to the Internet and its potential uses.

Students in the participating elementary schools also benefit. They mention that the activity offers "a real reason to share your thinking." Motivated by an outside audience, students increase their mathematical communication skills and learn to work collaboratively.

For more information contact Dawn Poole, Iowa State Instructor, at: **dmpoole@iastate.edu**

OFFLINE MAIL READERS

Internet service providers typically charge you for the amount of time you spend online. Although they often include a certain number of "free hours," your costs eventually increase as you spend more time online.

One way to save money is to use email software that allows you to read and compose email offline. By using this type of software, known as an offline mail reader, you don't pay for the time it takes you to compose email. This might not seem like a big deal when you consider one email message but it can make a big difference, particularly when students are involved.

To find out if your email software includes an offline mail reader, contact the manufacturer's technical support. If your software doesn't include an offline mail reader, you might want to consider switching to a package that does.

Here are names and contact information for select software that include an offline mail capability.

Eudora Light & Eudora Pro

800-2EUDORA

quest-rep@qualcomm.com

America Online

800-827-6364

info@aol.com

Internet in a Box

800-557-9614, ext. 52

iboxinfo52@spry.com

In their first message, the Maniacs did a wonderful job of explaining their reasoning but misunderstood the question.

> Dear Maddie,
>
> We thought this problem was easy. We got 14 games altogether. The way we got this answer was by subtracting 1 from 8, since you said Iowa State was one of the teams and we knew that they wouldn't be playing themselves. Next, we multiplied the 7 teams by 2 because they played each team twice. Our answer is 7 x 2 = 14 games altogether.
>
> Your friends,
> The Math Maniacs

Maddie quickly sent an email, informing them that the question asked for "the number of games played between all the teams, not just the number of games that Iowa State played." After a short discussion, the Maniacs fired off another message.

> Dear Maddie,
>
> We think the answer to the basketball problem is 98. We got this answer by multiplying the 14 games that Iowa State played by the number of teams altogether, except Iowa State. 14 x 7 = 98. We thought the answer should be bigger than 14 since you said NOT JUST Iowa State.
>
> Your friends,
> The Math Maniacs

Maddie responded with a new suggestion, encouraging the children to rethink their answer.

> Dear Math Maniacs,
>
> Unfortunately, the basketball answer is still not correct. It's a tricky problem. I'll try to explain it a little more clearly. I think that you are counting the teams more than once when figuring the answer. For example, if you count team #1 against team #2, then when you start to count team #2's games, don't include that first game since you already counted it. I hope that makes sense to you. If not, let me know and I'll try to explain it another way.
>
> Good luck again,
> Maddie

Normally, the Maniacs and my other fourth graders begin to show less enthusiasm after the second pass at a problem. Their interest flags and they explain less of their reasoning. This time the students seemed hooked, determined to finish what they'd started with their Iowa State helper. After an animated discussion, the children reached a consensus and motioned for me to come over.

"Mrs. Yantosh," Megan began, "We need help. Maddie sent us a new hint but we don't know what to do."

Thinking quickly, I tried to help them brainstorm approaches that might lead to a breakthrough.

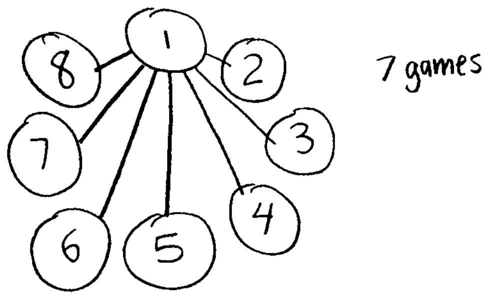
"There are lots of different teams and games in this problem. How could you make it easier to keep track?" I asked.

"Use a table," Samuel suggested.

"Or a picture," Megan said.

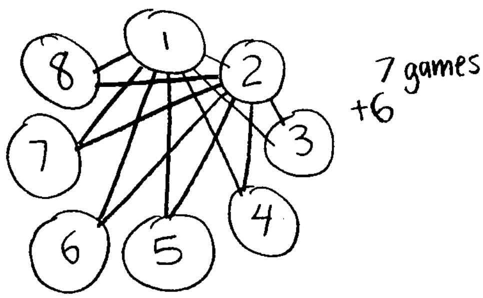
"What might a helpful table or diagram look like for this problem?" I asked.

Megan hesitated a moment and came to the board.



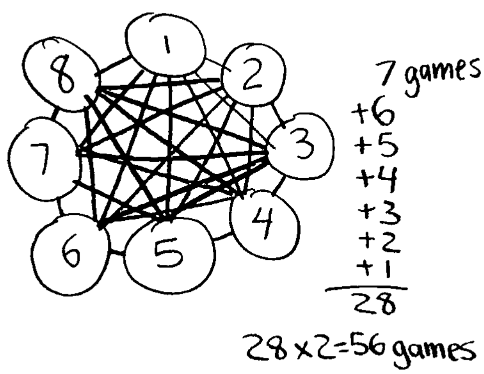
"These are basketballs," she explained. "Each basketball stands for a Big Eight team. The lines stand for games. By counting lines we know that team one plays seven games."

The Maniacs thought about Megan's diagram for a few minutes. Keisha volunteered to do the next step and added six new lines to the diagram.



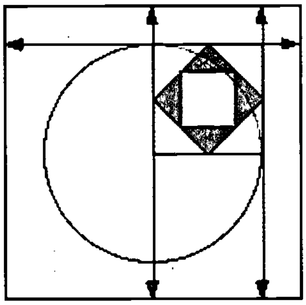
"This time we only needed six lines," she said, pointing to each in turn. "The line that shows the game between team one and team two is already there."

The Math Maniacs completed their diagram and sent their new answer of 56 games to Maddie.



ONLINE MATH RESOURCES

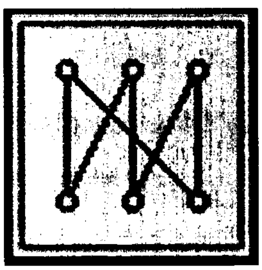
Math education resources, although less readily available than science education resources, provide a wealth of information, activities and support. The Web sites listed below highlight a few math resources and provide a way of connecting with dynamic communities of math teachers and students.



The **Math Forum** is an electronic community of K-12 teachers interested in geometry and math education. Forum participants share curricular resources and activities and discuss current math teaching practices. The Forum Web site also includes demonstration copies of geometry software such as Geometer's Sketchpad and Cabri Geometry.

webmaster@forum.swarthmore.edu

http://forum.swarthmore.edu/



MathMagic facilitates student activities designed to promote the development of problem solving and communication skills. Participating students work in multi-school teams to discuss and solve non-routine problems.

alanh@laguna.epcc.edu

http://forum.swarthmore.edu/mathmagic/

Since everyone in the project uses fairly simple email software that only transmits text, the children couldn't share their diagram and had to describe it in words. Although it was frustrating, this limitation put even more emphasis on student communication skills.

An hour later, I was still thinking about Maddie and the Math Maniacs. Walking into the staff lunch room, I plopped into a seat next to Caroline. Several of her seventh grade students, also paired with Iowa State students, were working on the same problem so the two of us had been swapping stories all week.

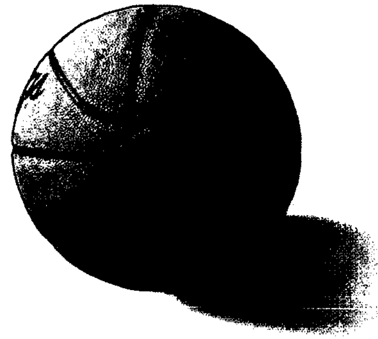
"So what's new?" Caroline asked.

"The Maniacs really struggled but they kept on working and used a diagram to solve the problem," I said with a big smile.

"I wonder why they chose to use a diagram," Caroline said, thinking out loud. "Raymee's group decided to act the problem out. Two of the girls remembered an old homework problem they had worked on earlier in the year and suggested using that strategy again. The girls recruited other students to help and had everyone act out the problem. Each of the eight students represented a Big Eight basketball team. They represented games with handshakes, counting them to come up with an answer."

I had been thinking about sharing this strategy with the Maniacs and other students in the class. Although student groups usually work on different problems, this time all three groups had been assigned the same one. Perhaps the entire class should spend time together and look at different ways of representing and solving the problem. Each group could describe how they worked on the problem and I could introduce another method, the acting-the-problem-out technique Raymee and the other seventh graders used.

Caroline and I talked about the idea as we finished our lunches and rushed back to class. As I considered different ways of initiating a whole class discussion, I thought again of my original questions. How can we encourage students to talk and write about mathematics? How can we help them to make connections between different representations of mathematical ideas? In this case, the Internet provided an exciting way to talk and write about mathematics. The focused give and take with someone outside the classroom context engaged students in a new and meaningful way, motivating them to go that extra distance, and to struggle with different methods of conceptualizing the problem until they achieve success.



QUESTIONS & ISSUES

MATHEMATICAL COMMUNICATION AND LANGUAGE ISSUES

Like the authors of this story, many teachers are coming up with new ways to foster student communication about mathematics. How does an instructional emphasis on talking and writing mathematics affect second-language learners and English-speaking students with poor language skills? Are there ways of structuring activities and language usage to accommodate students with different skills and histories?

GENDER ISSUES

Several teachers who read drafts of this story wondered why the Iowa State college student decided to assign the basketball problem. Which students might find this problem familiar and appealing? Which students might not? Are there problems which include similar mathematics but have a better chance of appealing to all students, regardless of gender, ethnicity or other characteristics?

LEARNING TO TEACH

Maddie and the other Iowa State college students are learning how to teach elementary mathematics. For some of them, this means developing deeper understandings of the subject-matter itself. It can also mean examining how students understand and sometimes misconstrue mathematical strategies and concepts. How can working with elementary students through email help preservice teachers develop the skills and knowledge they need to become effective teachers of mathematics? What are the limitations of this activity?

CONFESSIONS OF A FOURTH GRADE NEWBIE

GLENN LIDBECK

Magnetism is a required topic in our fourth grade science curriculum. We want our students to become familiar with basic properties of magnets: the way they push and pull on each other and interact with things made of iron. I find that my students grasp these ideas easily. It's the more abstract things that give them trouble. It's tough for them to make the connection between the Earth's magnetic field and the force field of simple bar magnets.

Looking for ways to help them make this link, I scoured the school library and discovered a simple activity: measuring the magnetism of the Earth. Students could make compasses and measure the relative strength of the Earth's magnetic field (see sidebar page 45). In addition, we put another spin on this tried and true experiment by collaborating with students at other schools.

All the participating classes would measure the Earth's magnetic field and exchange data via email. If classes around the globe conducted the experiment, we would have enough data to describe the Earth's magnetic field. We might even be able to locate the position of the magnetic North and South Poles!

We were new Internet users and had been exchanging email with scientists as part of the Live from Antarctica (see sidebar page 44). Perhaps other Live from Antarctica (LFA) teachers and students would be interested in participating in our experiment.

Coincidentally, the next LFA episode focused on the South Pole. Eyes glued to the TV, the students watched as a high school student ceremoniously moved the marker to its correct position. The *geographic* South Pole marker needs to be repositioned each year since it is planted in shifting sheets of ice.

My fourth graders loved this episode and wanted to know more about the South Pole. Knowing that many other teachers and students had seen the LFA episode, I felt sure that some of them would be interested in working with us and decided to move forward with the experiment.

The first step was to develop a lesson plan and do the experiment with my students. I began the lesson with a concrete example: a bar magnet displayed on the overhead with iron filings sprinkled around it. I overlaid a sketch of the Earth, pointing out the magnetic and geographic poles.

"The Earth's magnetic field is similar to the one revealed by iron shavings around the bar magnet," I explained. Tentative heads nodded in agreement, many no doubt envisioning a giant bar magnet poking out of the Antarctic coast at one end and out of an island in Canada's Hudson Bay at the other. "Okay, now we're going to do an experiment that will help us 'see' the Earth's magnetic field by measuring the number of times a compass needle oscillates in one minute."

Students worked in teams of two and constructed compasses—little thread and needle contraptions that pointed north quite reliably. Releasing the needle from its "east" position, they counted the num-

EISENHOWER NATIONAL CLEARINGHOUSE

The Eisenhower National Clearinghouse (ENC) offers print and electronic resources, including a comprehensive catalog of science and mathematics curricular resources. Catalog listings include a short description and information about how and where to get the item. In some cases, the entire resource is included in the catalog listing. The listing for *National Council of Teachers of Mathematics' Curriculm and Evaluation Standards*, for example, includes the entire document (text and graphics)!

For more information, contact ENC at:

info@enc.org

http://www.enc.org/

ENC also offers information by phone and fax:
voice: 800-621-5785
fax: 614-292-2066

ber of oscillations. There were a few problems—Aisha's needle kept spinning around, Nicole and Justin insisted that their needle would not balance—but everyone managed to complete the experiment.

Their results were all over the map, ranging from 13 to 27 with a class average of 26. I'd done the experiment earlier and recorded 16 oscillations. Something wasn't right but I didn't want to dispute their results. I felt that they needed a chance to reevaluate their work on their own.

I developed a call for participation and posted it via the LFA Teachers' Forum. Teachers and students from across the country responded enthusiastically. We even received email from classes in Australia and Japan! My students, who were becoming adept email users, monitored our class account. "You guys! We've got mail!" would bring children flocking to the computer. Over 60 schools expressed interest in the lesson.

Students were responsible for checking our email and responding to people's questions. Several teachers asked for more specifics about the experiment.

"Won't the mass of the needle influence how quickly it oscillates?" emailed Sofia Sanchez, an Earth science teacher in Los Altos, California.

"What about the thickness of the thread?" asked Rachel Milne of Tulsa, Oklahoma.

As they pondered these questions, the students started thinking more carefully about the experiment. Which variables did we want to change and which ones needed to be held constant? Did things like needle mass and thread thickness matter? If they did, how would differences affect the number of oscillations? As the students discussed teachers' questions, they started to really understand the experiment.

At the end of the six week data collection period, 11 schools sent in results. The measurements ranged from 13 to 20. I watched and waited, hoping that the students would compare their results with the incoming data. Although they were excited to receive the data, no one thought to make the comparison.

Wanting to expedite things but have them come to their own conclusions, I suggested that "as hosts of the experiment, we should be very confident about our own data before we publish the results." How sure were we? How could we be more sure? A lively class discussion ensued and the students decided that four of them should repeat the experiment.

Nicole, Aisha, Emily and Rebecca volunteered. Three of the girls counted 17 oscillations but Rebecca's results consistently clustered around 24. Frustrated that her results were so different, she seemed ready to give up. The other girls tried to help.

LIVE FROM ANTARCTICA

Part of the Passport to Knowledge Project, Live from Antarctica (LFA) was an interactive television series that aired during the 1994-95 school year. Participating K-12 teachers and students became Antarctic co-investigators as they exchanged email with research scientists at the South Pole, watched live television programs, and conducted related hands-on activities in their classrooms.

Each Passport to Knowledge series focuses on scientific exploration of a remote region. Upcoming programs will highlight areas such as the Amazon Rainforest, the planet Mars and the Australian Outback. Passport to Knowledge is a collaboration of many different organizations, including educators, public television organizations, National Aerospace and Aeronautics Program (NASA) and the National Science Foundation.

For more information, contact Online Interactive Projects at:

http://quest.arc.nasa.gov/interactive.html

or Passport to Knowledge at:

http://quest.arc.nasa.gov/livefrom/passport.html

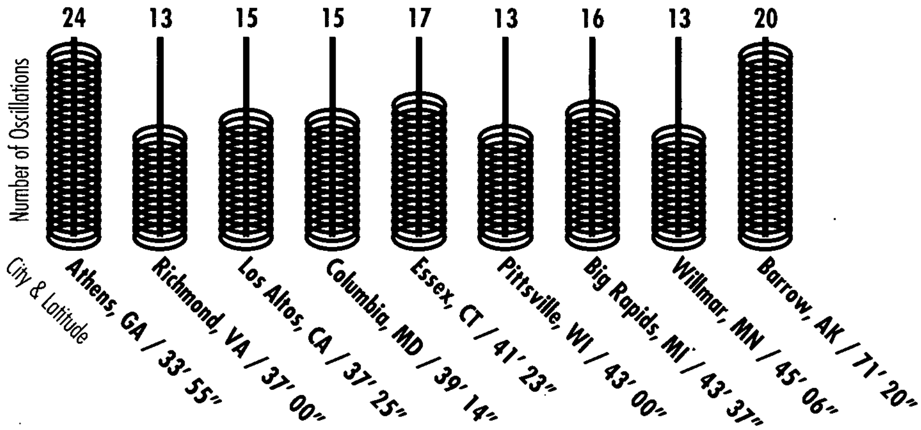
"Let's move your needle away from the table leg. Maybe the metal is confusing it," Aisha suggested.

"And look—there's a magnet here." Emily added. "Try moving it to another table."

Rebecca made another measurement and got 16 oscillations. *Yes!*

The girls reported their findings to the class. Everyone, including me, was amazed that the results could vary so easily. After a short discussion, the class decided to abandon their old results and use the new, more accurate data instead.

Working in teams of two, students then graphed the data from the 12 participating schools.



Just as we'd hypothesized, the number of oscillations was low near the equator and high near the poles. A few data points didn't follow the pattern. What was going on?

"Maybe they counted oscillations left and right," Aisha suggested, her team's spinning needle no doubt still fresh in her mind.

Justin offered a different idea, "Maybe they counted oscillations until the needle stopped *completely* instead of for one minute."

A few heads nodded. He and Nicole offered to find out and email schools whose data seemed off.

Fourth grade participants from Bathurst, Australia reported that they'd counted oscillations at twice our rate (left and right instead of one complete rotation to the starting point). They also mentioned that their needle was much smaller than the one we had used. After redoing the experiment, their results fell more closely in line with the others. Other schools reported similar inconsistencies in their methodology and, after repeating their experiment, emailed us new, more accurate results.

(continued page 47)

MEASURING THE MAGNETISM OF THE EARTH

The Earth's magnetic field varies with location. Students who perform this experiment near the North and South Poles, for example, will measure a stronger magnetic field than students near the equator.

Materials

(for each pair of students):

- small bar magnet
- blunt sewing needle
- approximately 18-inch long strand of silk thread

Please note that each pair of students must use similar materials to ensure consistent experimental conditions. If you are comparing your results with those of other students and teachers, remember to be very specific about the kind of needle, thread and magnet used.

Step 1: Magnetize the needle

Tie one end of the thread around the middle of the needle, making a tight knot. Stroke the needle with the bar magnet 20 times going lengthwise and always in the same direction.

Step 2: Count the oscillations

Hold the end of the thread so that the needle is suspended in front of you. Make sure that the needle is well-magnetized by checking to see that it points north-south. Next, carefully turn the needle 90° so that it is pointing east-west. Let go of the needle and immediately begin counting oscillations. Continue counting for one minute. Each oscillation will include a full cycle of movement—the needle will begin and end in the same position.

The number of oscillations provides a relative measure of the Earth's magnetic field. A large number of oscillations indicates a strong magnetic field; a small number indicates a weaker one.

DESIGNING YOUR OWN ONLINE PROJECT

Planning and organizing an online project can be a big job, but offers flexibility and opportunities for students and teachers to take on leadership roles. How can you ensure a successful learning experience for all project participants? This article includes tips from two of the experts: Al Rogers, award-winning executive director of the Global SchoolNet Foundation and Judi Harris, author of "Mining the Internet", an excellent column published in *Learning and Leading with Technology*.

DETERMINE YOUR GOALS

Begin the planning process by looking at the big picture. What do you want students to learn? What skills do you want them to develop? Identify goals first, before you develop an activity and find teachers and students to work with. This important step can help you maintain a strong focus and create a project that fits into your curriculum.

This is also a good time to ask yourself if Internet tools and resources will help students to achieve the goals you've identified in this particular project. If the tool fits the task, use it. If it doesn't, then by all means, use a different tool. The key to effective Internet (and other technology) use is to be specific about what you want to do and then use the teaching and learning tools that are most appropriate.

MAP OUT THE DETAILS

Once you've decided what you want to do, it's time to work out the details. How will you structure the activity? What will participating students and teachers need to know? How can you describe the project to spark their interest?

As you develop answers to these questions, you will need to prepare two email messages to distribute to potential participants: a short project announcement and a longer, more detailed call for collaboration. The project announcement consists of a short description of the project and contact information so people can request further details. The call for collaboration includes all the information teachers and students will need to participate in the project:

- Project goals, objectives and description
- Your contact information: name, location, email address
- Firm timeline that includes a beginning date, ending date and several interim tasks and deadlines
- Criteria for participation: how many teachers and students will participate in the project? which grades will be included? how will you select participants? when and how will you let teachers and students know if they will or will not be included in the project?

Many teachers use sample project announcements and calls for collaboration as a guide for writing their own messages. Examples developed by other teachers can give you valuable ideas and help you to successfully organize and describe your own project.

It also helps to have a friend or colleague take a fresh look at your project announcement and call for collaboration. Are the messages clear? Do they include the information teachers and students will need to make decisions and participate in the project?

You might also want to test your project out on a small scale, either with one teacher or with a group of teachers. A quick trial run can help you discover technical problems or glitches in the overall project design, saving time and unnecessary frustration in the long run.

FIND PEOPLE TO WORK WITH

After you've thought through the details, it's time to get the word out. Start by sharing your project announcement with other teachers who have Internet access. This can be easily accomplished by posting your annoucement on one or two electronic mailing lists where teachers advertise their online projects. Interested teachers and students will send you email, expressing interest and requesting more information (the call for collaboration).

It's hard to know how many teachers will want their students to participate in the project. There may be ten, there may be one hundred. It's your job to decide how many participant groups work best for the project, select participants as necessary, and let everyone know what's going on.

KEEP UP THE MOMENTUM

Once teachers and students are actually participating in the project, your role as project facilitator becomes doubly important. Here are a few tips to keep discussions focused and lively.

- Form a distribution list of all project participants, so that teachers and students can share information and materials easily.
- Focus discussions on the originally defined topics and tasks.
- Share your expertise with others and encourage other participants to do the same. This can become particularly important when participants are Internet newcomers and need technical assistance.
- Encourage participation by sending short, private email messages as necessary.

  reminder messages help busy teachers and students remember upcoming tasks and deadlines

  cheerleader messages recognize and applaud exceptional efforts

  ping messages touch base with participants who have not sent email to the group for a while

  thank you messages can be sent throughout the project to let participants know that you appreciate their contributions

END GRACIOUSLY

Projects often include development of a tangible product that will become accessible to project participants and to the larger educational community. The product might be a book, short videotape, or online database of measurements collected by students. The point is to create something concrete that showcases all the hard work and rich learning that have taken place.

It's also helpful to include time for participants to talk at the end of the project. Students and teachers might share their perspectives informally with one another. They might also choose to close with thank yous and goodbyes or by planning to collaborate again in the future.

(continued from page 45)

As I look back on this project, I consider my original goals. Did my fourth graders make the connection between the properties of simple bar magnets and the Earth's magnetic field? Did our experiment make this phenomenon easier to understand?

I think that the answer to these questions is yes. Aisha and Emily told Rebecca to move away from magnets and potentially magnetized objects because they knew that these things exerted the same kind of force as the Earth's magnetic field. Similarly, students were able to make suggestions to other schools because of their own experimental experiences.

All of these things happened because the kids were excited and involved. They took some responsibility for their own learning and felt free to explore directions that were meaningful to them. They learned by doing. They made a difference in their own lives and in their community (see sidebar this page). None of this could have happened without communication with people outside the school. This is the potential that Internet carries—the potential to bring us together and to help us learn from one another.

STUDENTS TAKE ACTION

While the magnetism experiment was going on, Glenn's class was also working on a legislative activity with Mr. Marchei's fourth graders across the hall.

Together, they drafted an Internet access bill to the Connecticut General Assembly. Essex Elementary had to make a toll call each time it connected to the Internet while East Flanders Elementary, another school only ten miles away, paid nothing. Students felt that the situation was unfair and took action. To promote their bill, students wrote letters, urged parents to call their state senators, and even visited the state capitol to lobby their legislators.

Although the bill did not pass, students did accomplish their goal. The Public Utility Commision, prompted by widespread community support, redrew the telephone calling areas, making Internet access a local call for the entire community.

QUESTIONS & ISSUES

DEVELOPMENTAL AND CURRICULAR ISSUES

Glenn's magnetism project involved students and teachers from elementary, middle and high school. For some teachers, this aspect raises developmental and curricular issues. How can the project fit into the fourth grade curriculum? How can it fit into an honors physics class for high school students? Although cross-grade collaboration has clear advantages, it also creates challenges for teachers and students seeking to contribute to the group effort and explore developmentally appropriate concepts.

Since many online projects involve students and teachers in different grades, this is a common issue. One suggestion is to conduct different investigations with the same data set. Glenn and his fourth graders focused on changes in the Earth's magnetic field with respect to location. High school students might, on the other hand, investigate a more complex problem such as characterizing the fluctuations of the Earth's magnetic field over time.

CHALLENGING STUDENT DATA

Glenn consciously decides not to challenge student data from the magnetism experiment. What are the implications of this choice? How does it reflect the skills and concepts he is trying to teach?

As the story progresses, Glenn expresses concern that students are not reevaluating their own data. Why didn't this happen? Students are clearly engaged and on-task. What assumptions or misunderstandings prevent them from seeing problems in their own data?

VARIABLES

Teachers who read drafts of this story noted the instructional emphasis on understanding variables and experimental design. As the fourth graders communicated with students and teachers at other schools, they explored experimental differences caused by using different kinds of threads, needles and magnets. They also identified magnetic phenomena that could interfere with their experiment. What aspects of the project contributed to this level of student ownership and attention to experimental method?

Branching Out

DESERT STUDIES

SUSAN HIXSON

Cheers rang out as the yellow school bus pulled to a stop at the Phoenix Desert Botanical Gardens. Rummaging through her backpack, Amber, a third grader from Carminati Elementary School, found her pencil, sun block and crumpled hat.

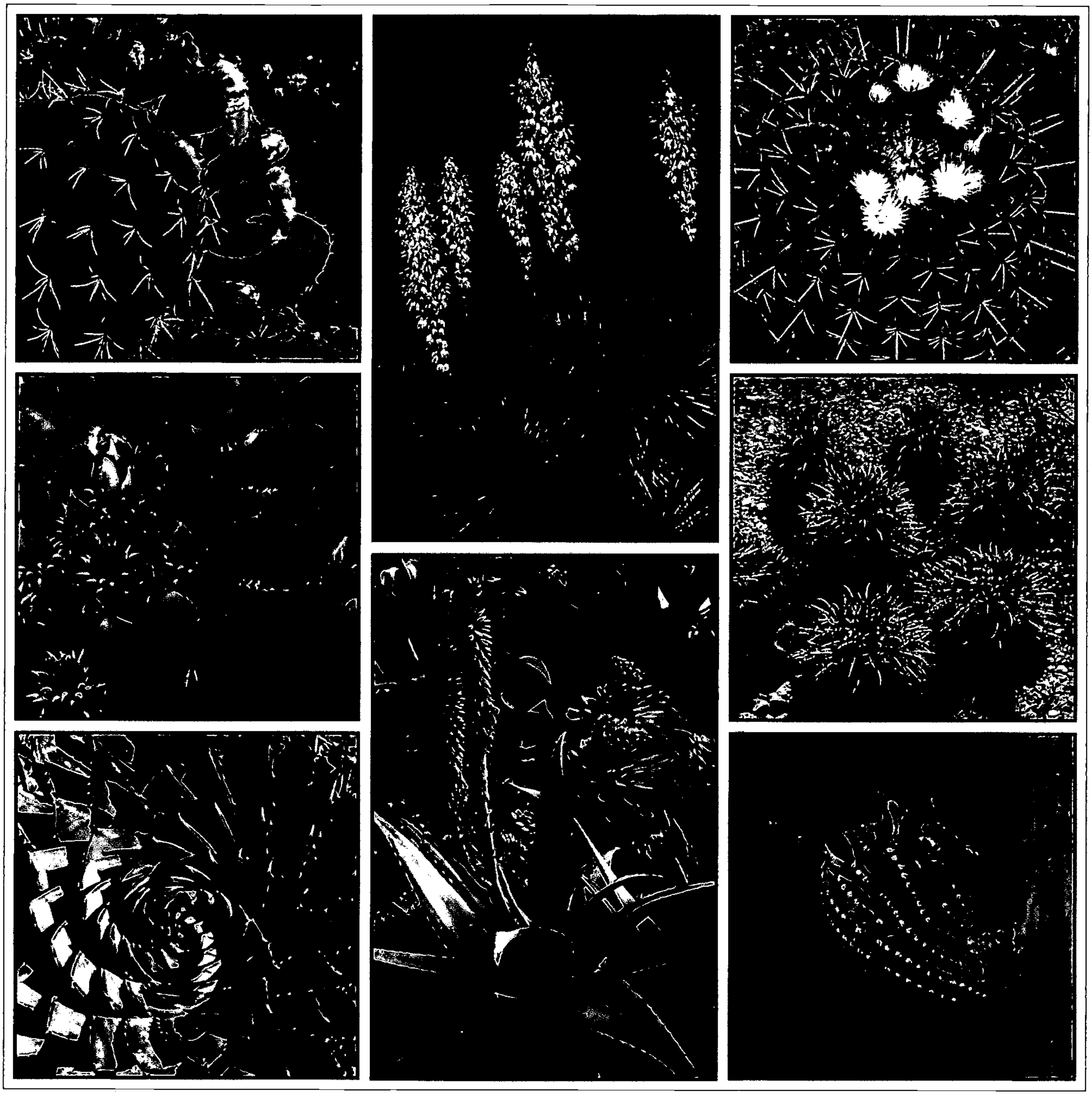
"I can't believe we're finally here," she cried out. "Did you see that paloverde near the gate? Just like in the book—the branches are really green!"

It was a gorgeous spring day and Mrs. Chan and Mrs. Smith's third graders were on a field trip. Part of a six-week unit on the Sonoran Desert, the field trip was the culminating event of a series of interdisciplinary activities. Students had done library research and conducted experiments but nothing could compare to this—investigating a model desert environment!

Planning for the unit began in the fall. The two teachers wanted their students to develop inquiry and communication skills and to learn about plant and animal adaptation. What features are common to local plants and animals and how do these features help them to thrive? How do plants and animals interact and depend on one another for food and shelter? The teachers were also eager to explore instructional uses of their new classroom computer and Internet connection. As they were unfamiliar with the Internet, they invited me to help with the planning and teaching.

I am a staff developer and divide my time between two schools: Carminati and Fuller, another elementary school in the Tempe Unified School District (Tempe is a large suburb in central Arizona, located just outside of Phoenix). When Mrs. Chan and Mrs. Smith approached me with their plans, I was thrilled. Both teachers had participated in a full-day Internet workshop I had organized earlier that year. Now they wanted to take things to the next level and experiment with this tool in a classroom setting.

Mrs. Chan and Mrs. Smith have constructed an unusual classroom



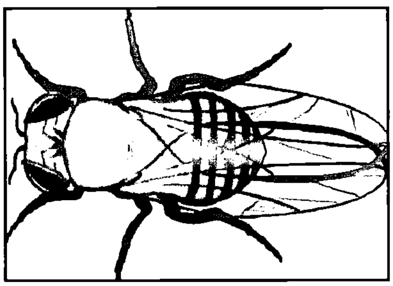
environment. The two teachers share a double-sized room and group their students together. Each day Mrs. Smith's ten students with disabilities work side by side with Mrs. Chan's group of third graders. This rich, more inclusive learning environment has worked out well for students and parents alike and has given the two teachers countless opportunities to team teach and share resources.

As we talked about goals and lesson plans, I started to identify some of their key questions. How would using the Internet affect student learning and enthusiasm? How would it be different from using a textbook or CD-ROM? How might the needs of learners

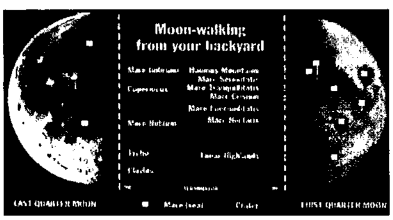
VIRTUAL FIELD TRIPS

Science and technology centers provide a wide variety of online resources including exhibits, teacher materials for planning field trips, and parent information for involving families in scientific inquiry.

The **Museum of Science in Boston** offers resources for local and global communities, including a series of scanning electron micrographs.
http://www.mos.org/



One of the first science centers on the Web, San Francisco's **Exploratorium** provides curricular resources and online exhibits. Their Learning Studio, which includes an exhibit called Mutant Fruit Flies, is something you don't want to miss.
http://www.exploratorium.edu/



The **Franklin Institute in Philadelphia** shares resources for home and classroom activities such as this electronic map of the moon.
http://sln.fi.edu/

with differing abilities be addressed? The teachers were also concerned about the student to computer ratio: how could they accommodate all 37 students with only one classroom computer?

After our preliminary discussion, I sat down and thought about the teachers' questions. All of them raised tough, important issues. Since this was the teachers' first time using the Internet, it was important that the unit go smoothly, providing them with experiences to answer their own questions.

I had recently read about virtual field trips—electronic excursions in which students "go" to a science center or museum by accessing that organization's World Wide Web site (see sidebar this page). Some science centers have developed online, interactive exhibits that are similar to the actual exhibits at the center. Other organizations, such as museums, include images of artwork so that Internet users can see what people at the museum see.

We had already decided to go on a field trip to the Phoenix Desert Botanical Gardens. Perhaps students could go on several virtual field trips as well. Surely plants from other states and countries would exhibit different adaptive features and provide new opportunities for student learning.

Looking for rich, interactive resources, I explored the World Wide Web and quickly discovered a number of Web sites developed by botanical gardens in different climates.

Australian National Botanical Gardens
http://155.187.10.12/anbg/anbg-introduction.html

Royal Botanic Gardens
http://www.rbgkew.org.uk/

Missouri Botanical Garden
http://www.mobot.org/welcome.html

Many of them provided excellent color pictures accompanied by simple, easy-to-read text. Students could work in heterogeneous groups to help each other view and understand information at these sites.

I also wanted the teachers and students to realize that they could publish their own material on the Web. Maybe we could develop our own Web page to describe plants at the local botanical gardens and our impressions of the outing. Although I had never published anything on the Web before, my email contacts in other schools assured me that it was easy and that, with a little help, I would do fine.

When I suggested these ideas to Mrs. Chan and Mrs. Smith, they were intrigued. Both ideas seemed promising and we decided to incorporate them into the unit.

The three of us had collaborated on many projects, including process-writing projects in which students wrote and illustrated their own books. These books were then published in our publishing center and exhibited as part of the school open house. All of us, having never tried electronic publishing before, were curious to see how it compared to print publishing. Would students feel as much ownership of the final product? Would their excitement help them to focus and learn?

Students began the unit with an in-class activity. Working in teams of three or four, they made observations and illustrations of ten cacti found in the Sonoran Desert. Each cactus was small, perhaps six inches tall, and had its own pot so children could move them and work at their desks. Some cacti had lots of arms arranged in a rosette pattern—how might this characteristic be helpful? Other cacti changed shape , becoming rounder and fuller when students watered them more frequently.

Students also compared the cacti with plants found in other climates. Each team accessed the World Wide Web sites I had marked and made notes in their science journals. Amber's team was fascinated by a giant cabbage they saw at the Alaskan Botanical Gardens. Grown by scientists studying natural cancer-busting substances found in edible plants, the cabbage was about the size of a large beach ball! Javier's group chose to focus on environments with heavy rainfall. Their journal included comparisons between local cacti and rainforest plants they saw at the Australian Botanical Gardens Web site.

Students took turns and did their online research during team study times. While one group used the computer, other groups focused on cacti in the room and did other tasks. After the first few teams completed their online work, Mrs. Chan suggested that we move the computer from behind her desk and into a bigger, more accessible space.

"After all, we'll be using it every day and students will need easy access," she remarked.

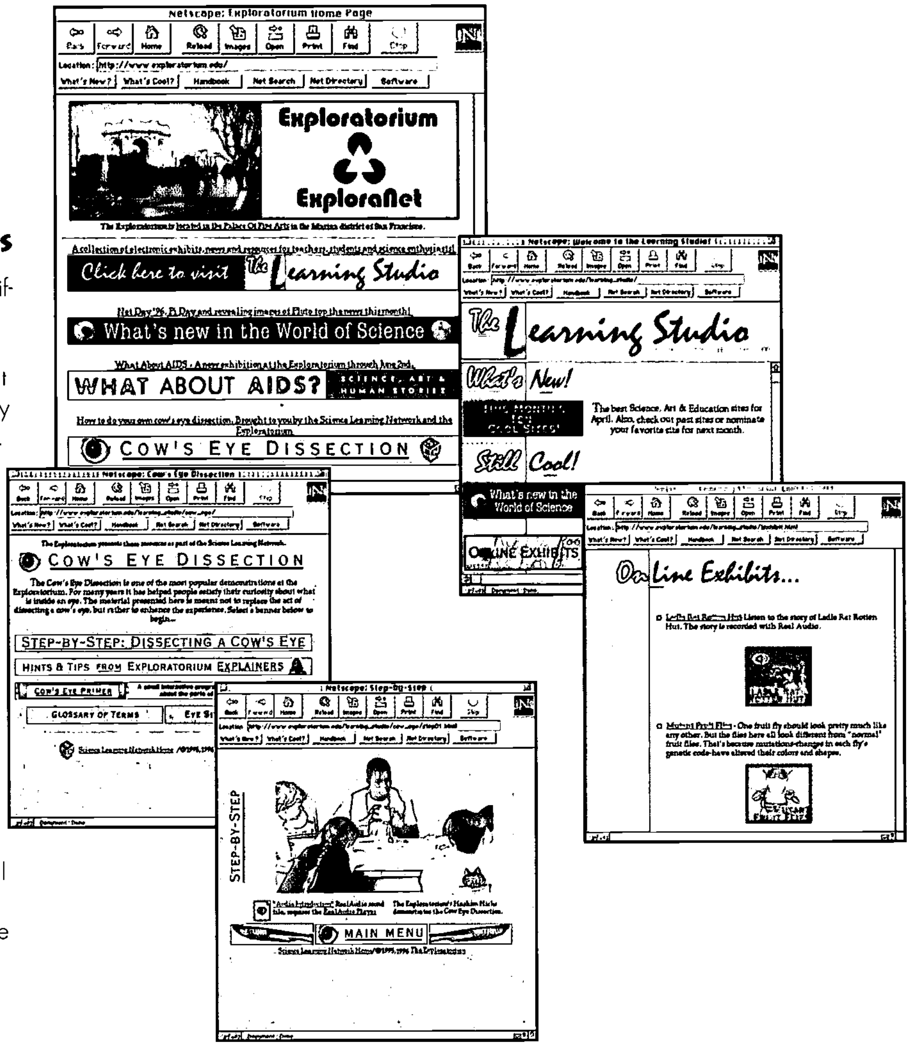
Although I was outwardly calm and nonchalant, deep inside I was delighted. The teachers had undergone a real change in thinking. At the beginning of the unit, they had questions about the usefulness of Internet tools and resources. Now they were allocating precious classroom space to foster student computer use. At some point, Mrs. Chan and Mrs. Smith had made their decision: the Internet was a valuable tool for student learning and needed to be available to students during this unit and future lessons.

I joined the class for a few minutes each day to help and see how things were going. Both teachers had become very comfortable with the technology and often explored the Web themselves, looking for curricular resources after class.

(continued page 55)

WORLD WIDE WEB

World Wide Web—often referred to as the Web—helps Internet users find and access information. Web resources can include text, graphics, sound and video and can refer or link to other Internet resources. The figures show a series of sample Web windows.



WORLD WIDE WEB ADDRESSES

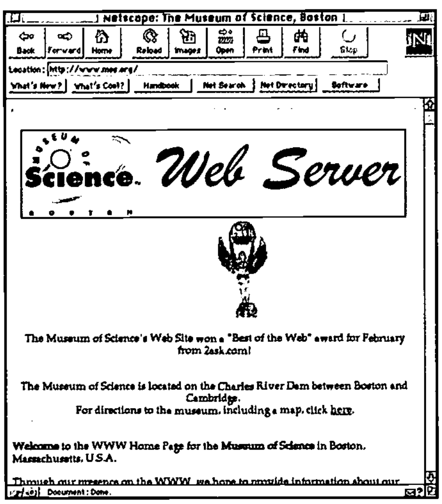
This book includes references to many different Web resources. Each reference specifies a Universal Resource Locator (URL). Although they sometimes look a bit cryptic, URL's are simply addresses. Every file on the Internet has a unique address. The electronic version of this book, for example, has the following URL.

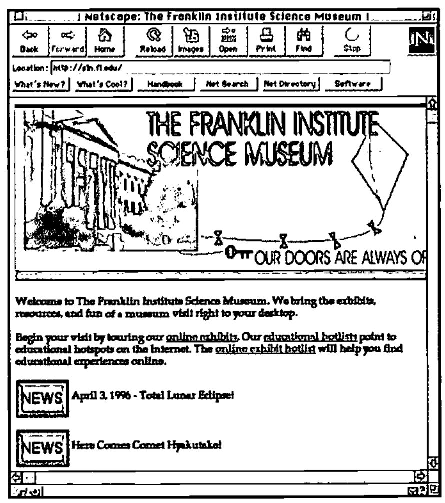
http://www.wested.org/tales

By using Web software to "open" the URL's listed in the Virtual Field Trips sidebar (page 52), you can also access Web pages developed by the Museum of Science and Franklin Institute.

WEB SOFTWARE

Choosing Web software is a process that is most easily done with help from your Internet service provider. Contact their technical support staff through email or a phone call. Do they offer World Wide Web service? If so, what software do they recommend and support? Is it compatible with your computer system? Some Internet service providers may not offer World Wide Web service. If your provider doesn't, you might want to start thinking about other options.





(continued from page 53)

After a few weeks, students began preparing for their trip to the Phoenix Desert Botanical Gardens. The idea was that each team would focus on a different plant, collect first-hand observations at the botanical garden and then write a team report back in the classroom. The reports could be woven together and published on the World Wide Web, creating an indepth, student-generated portrait of the botanical gardens and our visit there.

When the big day arrived, everyone was excited and ready to go. Each team explored the garden with a parent or teacher and made measurements and observations. Amber, Javier and Erika, the three students in my group, had chosen to research cholla cacti. Roaming the paths, they looked at different cholla cacti and took careful notes. How tall was each cactus? What color was it? Did it grow alone or near other cacti? Did animals rely on it for shade or protection? After combing the entire garden, Amber, Javier and Erika decided on the perfect cholla cactus and snapped several photographs. Hopefully, one would turn out just right and could be used for our Web page.

The day after the trip, the third graders gathered on the carpet to begin work on the cactus reports. What observations should we include? Who would be reading our reports? What might they want to know? Students continued to work in their teams as they wrote their reports and critiqued each others' work.

When the reports were completed, I collected the papers and began constructing our Web page with the help of Jon, a graduate student at Arizona State University. Although I expected the process to be very difficult, it turned out to be quite quick and easy. The toughest part was processing students' cactus photographs so that they could be included in the Web page.

It was difficult to determine who was more excited—the adults or the children—when the class accessed its own Web page for the first time **(http://seamonkey.ed.asu.edu/~storslee/botan.html)**. Students pointed out different team contributions and congratulated each other on a job well done.

The students weren't the only ones who were impressed. I had worked with the developers of Kidopedia, a student-written encyclopedia on the Web **(http://rdz.stjohns.edu/kidopedia/)**, to link our page to other student work. Through this connection, we received several email messages from other students around the world, including a group from Israel. After viewing our Web site, these middle school students sent congratulations and thanked us "for showing them similarities between ecosystems in different areas of the world."

Mrs. Chan, Mrs. Smith and the third graders also received kudos from parents and teachers at Carminati's Math/Science Night.

SCHOOLS ON THE WEB

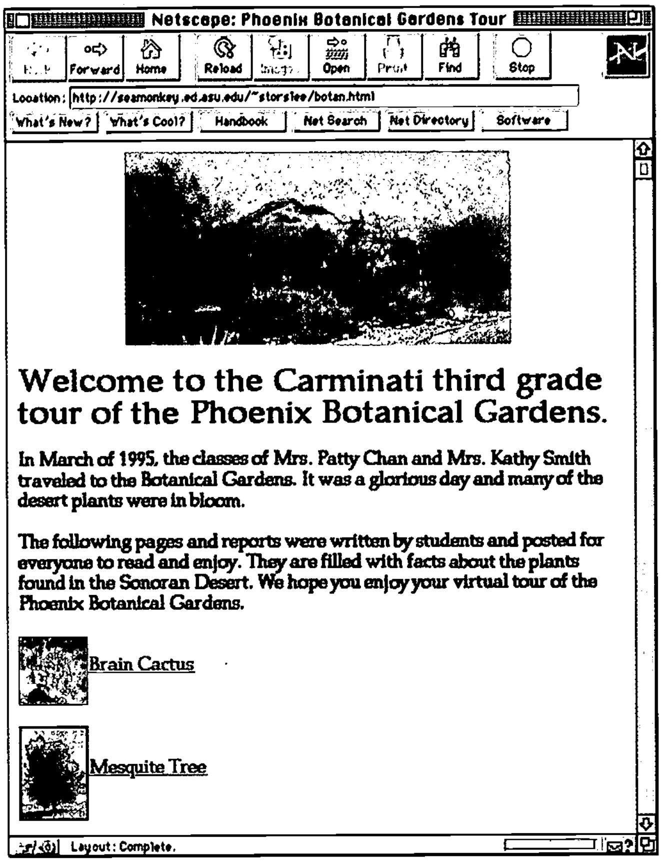
Teachers and students aren't just recipients of online information. They are also developing their own resources and publishing them on the Internet.

Located in New York City, the Web site for **Ralph Bunche School** shares information about school events and student projects. The Great Penny Toss, a probability investigation organized by sixth graders at the school, invites you and your students to toss a few pennies and participate in the activity.

http://mac94.ralphbunche.rbs.edu/

Each day, more classes and schools publish educational information on the World Wide Web. The **Web66** project helps teachers and students stay informed, serving as a directory of online schools. Their Web site also provides how-to information for schools interested in establishing a Web presence.

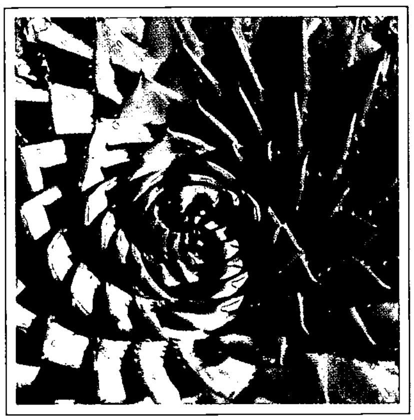
http://web66.coled.umn.edu/



Using their Web page as a way of presenting their work, several students shared the whole class's work and described how it fit into our Sonoran Desert study.

So many good things came out of this project. Mrs. Chan and Mrs. Smith began exploring the Internet and discovering ways of using it in their teaching. Students gained access to information and people that had not been as accessible to them. How could any school afford books and CD's with the diversity and amount of information accessible on the Internet? And how could those materials facilitate the kind of student-to-student interaction third graders experienced through this project?

I feel lucky to have been a part of this project. By participating, I learned new things: how to construct a Web page and how to use Web resources and electronic publishing to support the curriculum. I also had an opportunity to practice the kind of ongoing, in-the-classroom teamwork I believe is crucial to effective staff development.



QUESTIONS & ISSUES

IDENTIFYING REQUIRED RESOURCES AND SUPPORT

For some teachers, this story helps to define the resources and support needed to begin using the Internet for instruction. How did availability of classroom resources contribute to the unit? How did aspects of school culture and organization contribute? Most importantly, how did the tone and nature of teacher-teacher and teacher-staff developer interactions shape the unit?

ACCOMMODATING LEARNERS WITH DIVERSE LEARNING NEEDS

In this story, it's mentioned that students with differing ability levels all participate and learn through the project, but few specifics are given as to how this occurred. Several teachers who read drafts of this story brought up questions about students with disabilities and the Internet. What might the challenges be for teachers who wish to integrate students with and without disabilities, particularly in lessons that include Internet use? What kinds of support and expertise might be required to do this successfully? This story takes place in a third grade class. How might this teaching arrangement work with students in middle or high school?

OF WIND AND WEATHER

KRISTINE MUEH

The first year I participated in the Kids as Global Scientists project (see sidebar), I was intimidated by computers and could barely read my own email. It's now my third year and things are very different. I'm more comfortable with the technology and have learned how to use it with students. I've also developed a flexible, more responsive teaching style. My experiences with kids and the Internet have shaped my thinking in ways I didn't anticipate.

The first time I took my sixth graders to the computer lab I was really tense. Just getting there seemed like a big deal. I wanted the students to walk quietly: single-file, no banging on lockers, no talking to friends. Instead, they moved as a mob—some sprinting, some dawdling, some leaping toward the ceiling with outstretched arms. My anxiety increased as I issued stern warnings and helplessly shooshed them along.

I had constructed a lesson plan and wanted the kids to listen intently to my instructions, carry them out and then place their hands in their laps as they waited for the next instruction. Things didn't quite work out as I had hoped.

"All right, it's important that you follow my instructions," I began. "No skipping ahead. Reach behind your computer and flip the rocker switch. Double click on the email icon."

Just then I heard a keyboard clicking. "David, why are you typing?" I asked.

"We're already in our account, Miss Mueh," he answered.

"What did I say about not skipping ahead?!" Looking around, I noticed other groups typing covertly. "How many of you have already logged into your email accounts?"

Almost all the students raised their hands.

"So you know how to do this?" I asked.

"Yes, Miss Mueh," they replied, continuing to type.

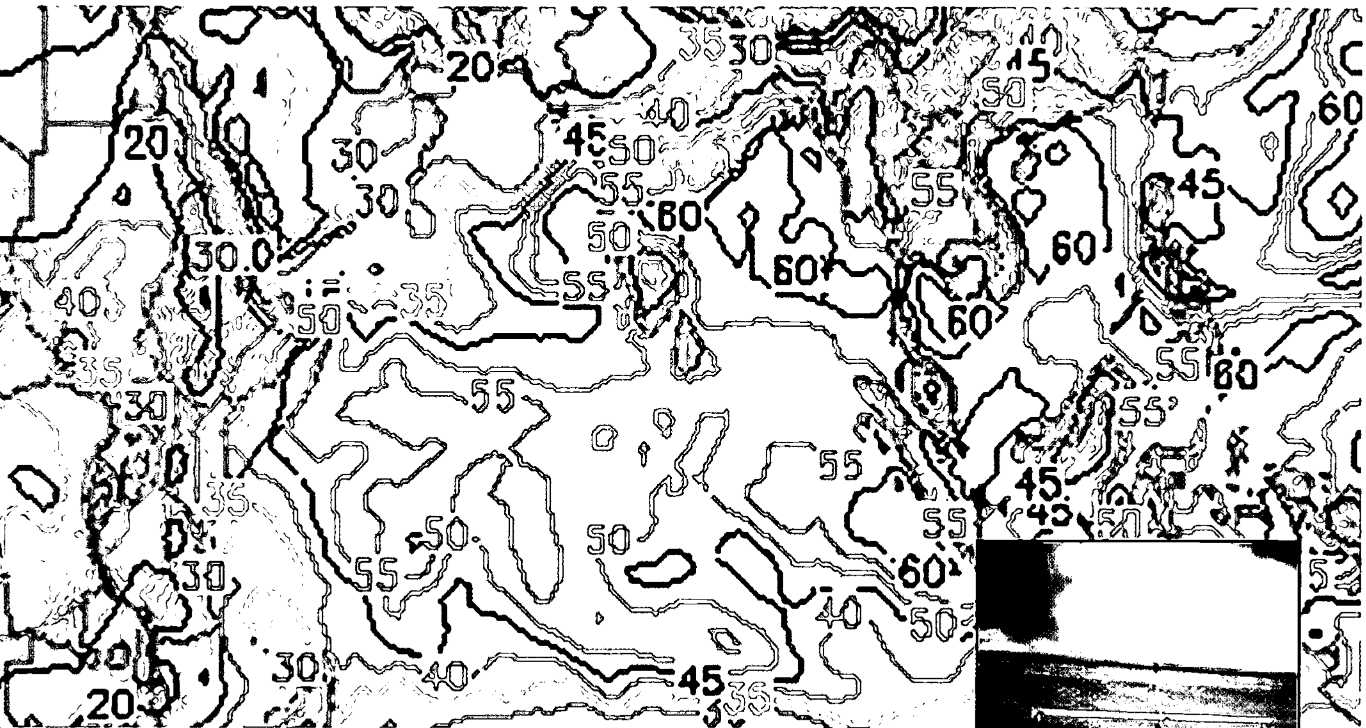
KIDS AS GLOBAL SCIENTISTS

Kids as Global Scientists is an international network of teachers and students studying weather. Organized around a flexible middle school weather curriculum, the project helps teachers and students to utilize the full educational potential of Internet tools and weather resources.

Project activities are done in coordination with other KGS schools over an eight week period. During this time, students collect their own weather data, discuss weather phenomena with mentors and students at other schools and access real-time weather images via the Internet.

Participants must have email access. Gopher and/or World Wide Web access is useful but not required. Project staff also recommend that students have access to simple weather data recording devices.

For more information:
kgs@spot.colorado.edu
http://stripe.colorado.edu/~kgshtml/Home.html



At first I was confused. How did they know how to log into their email accounts? As I watched, I realized that the students were teaching each other. At least one student in each group knew what she was doing. That kid, who must have remembered from Mr. Dixon's computer class, taught the other two in a fraction of the time it would have taken me to lead everyone through each key stroke.

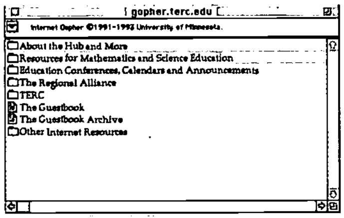
All of this made me start thinking about my own assumptions. How do student attitudes toward technology differ from my own? What prior knowledge do kids have and how can I help them to build on it? These questions came up during a computer lesson but I felt like they had implications for my Earth science teaching as well. Kids spend a lot of time outside. They collect rocks, they watch the sky, they fly kites. How can I help them to tap into their intuitive understanding of the Earth and its atmosphere?

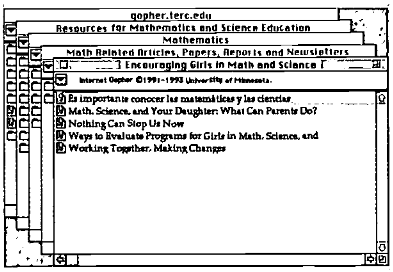
I also realized how effective student-to-student mentoring was in this lesson. I try to give kids opportunities to talk and teach one another in a structured environment. When does this strategy work? When is whole-group instruction more appropriate?

This year my first few Kids as Global Scientists lessons went quite smoothly. I determined how familiar students were with computers and the Internet before beginning the unit and assigned small groups to include students with varying levels of expertise. Each group chose a weather topic—clouds and humidity, winds, precipation, or temperature and pressure—and exchanged email with students at other hools who were focusing on that topic.

GOPHER

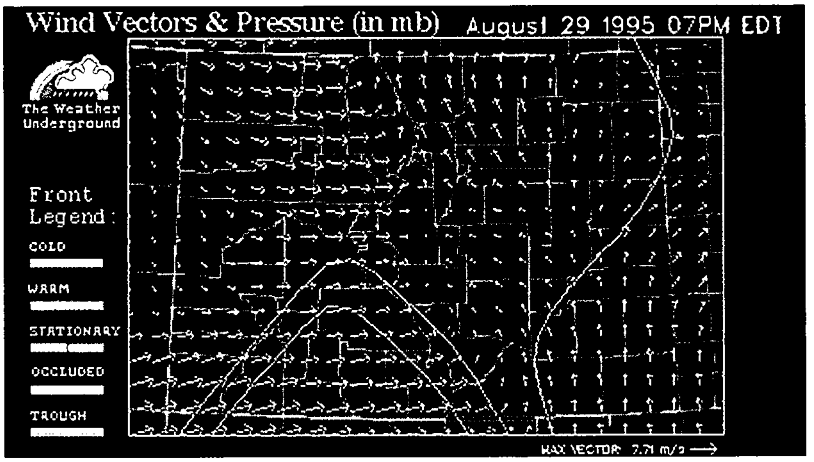
Gopher helps Internet users find and access information efficiently. By organizing resources and displaying them as a series of menu choices, Gopher helps users quickly get a sense of what is available and identify relevant resources. The figure below shows two sample Gopher windows.





If Gopher is new to you, start with a call (or email) to your Internet service provider's technical support staff. Do they offer Gopher service? If so, what Gopher software do they recommend and/or support? Asking these questions first can save you time and help you make smart decisions.

Michiko, Joshua and Amanda chose to concentrate on wind. A well-matched trio, they enjoyed the getting-to-know-you activities and happily exchanged email with other wind students. After a few weeks, they moved on to task number two: predicting future wind patterns using Internet resources and student-generated measurements of wind speed and direction. The three students used anemometers to measure wind speed and direction and shared their data with wind students at other schools. The data collection part was easy for them. Making sense of the Internet data turned out to be a little harder.



Rotating from group to group, I noticed Michiko, Joshua and Amanda slouched in front of their computer, looking frustrated. There was a real-time map showing Colorado wind patterns on their screen but no one was looking at it. What was wrong?

"So how does this Internet data compare with your wind data for today?" I asked.

"I don't know," Amanda replied listlessly.

"Well, here's our school," I said, pointing to Boulder. "What does this map tell us about the wind here in Boulder?"

No one said a word.

"Let's say you went outside right now. What wind speed and direction would you measure?"

"You mean they're the same?" Michiko asked.

So *that* was the problem! They weren't making the connection between the wind measurements they made every day and the wind data they accessed via the Internet! With a little guidance, the three students became more enthusiastic and began looking for patterns and making predictions. Amanda went outside to make wind measurements and double-check that the data displayed on the Internet map was indeed up to the minute. While she was gone, Joshua,

Michiko and I talked about high and low pressure areas, pored over the map and made a prediction. Zipping to a U.S. map, Joshua and Michiko were happy to discover that—as they had thought—a high pressure center had developed just to the east!

This incident really made me realize how abstract and difficult to understand Internet data can be. There is so much information on each weather map. How can I help my sixth graders find patterns and relationships? How can I help them to draw upon their hands-on experiences as they make sense of the fancy maps they see on the computer screen?

I'm also struck by the depth and level of student understanding that develops when students work on complex tasks like predicting wind and precipitation patterns. Assessing this knowledge is a challenge and has pushed me to experiment with different ways of measuring student learning. One of the things that has really worked for me is reading the email my students exchange with students at other schools. Although students know that I read some of their mail, they quickly forget and write with only other students in mind. Their messages are uninhibited and give me a richer, more indepth look at student thinking.

Michiko, Joshua and Amanda are all very shy, quiet people. They often prefer not to talk in class. When they answer questions, they typically offer straight-from-the-textbook answers. Although I'm pleased that they do their work, I often wonder how much they really understand or enjoy the material. Email has given them a more private forum to share their ideas with other students and has given me another means of gauging their progress.

Hello,

This is the winds group from Boulder, Colorado. Are you getting a lot of wind over there? We are getting a medium amount of wind today, mostly downslope winds called Chinooks. Do you know about Chinooks? They are winds that sweep down from the Rockies. They can be strong or soft winds. We see you on the map and you are right next to the Rockies, too. Are you getting a Chinook wind?

Sometimes we get winds up to about 100 miles per hour but we don't get them often. We would like to know about the winds in your area. What kind of damage do they do?

Sincerely,

Winds group

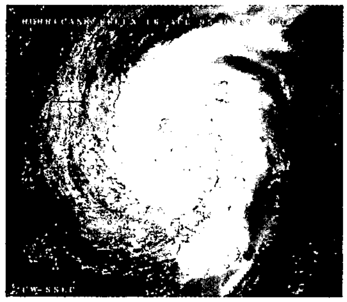
Hi winds group,

We don't get Chinooks here because we are too far north. Well, every now and then we get one, but not very often. We are not having one today. Calgary, to the south of us, and other cities like Lethbridge get them all the time.

We are lucky. Our winds almost never do damage, well not big damage. Once

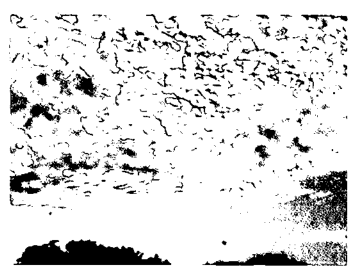
ONLINE WEATHER RESOURCES

Weather is a popular topic on the Internet and both educational and scientific research organizations offer resources for the K-12 community.



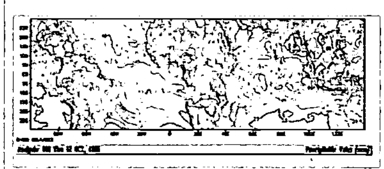
The **Weather Underground** offers resources and an online directory designed specifically for K-12 students and teachers. The site also features Blue Skies, a type of easy-to-use gopher software for accessing and viewing weather imagery.

http://groundhog.sprl.umich.edu/



An excellent resource for K-12 students and teachers, the **Cloud Catalog** provides information on cloud formation and stunning images illustrating different types of clouds.

http://covis.atmos.uiuc.edu/guide/clouds/html/cloud.home.html



The **Center for Ocean, Land and Atmosphere Studies** offers sophisticated climatology resources as well as current forecasts, research papers, and links to research scientists.

http://grads.iges.org/

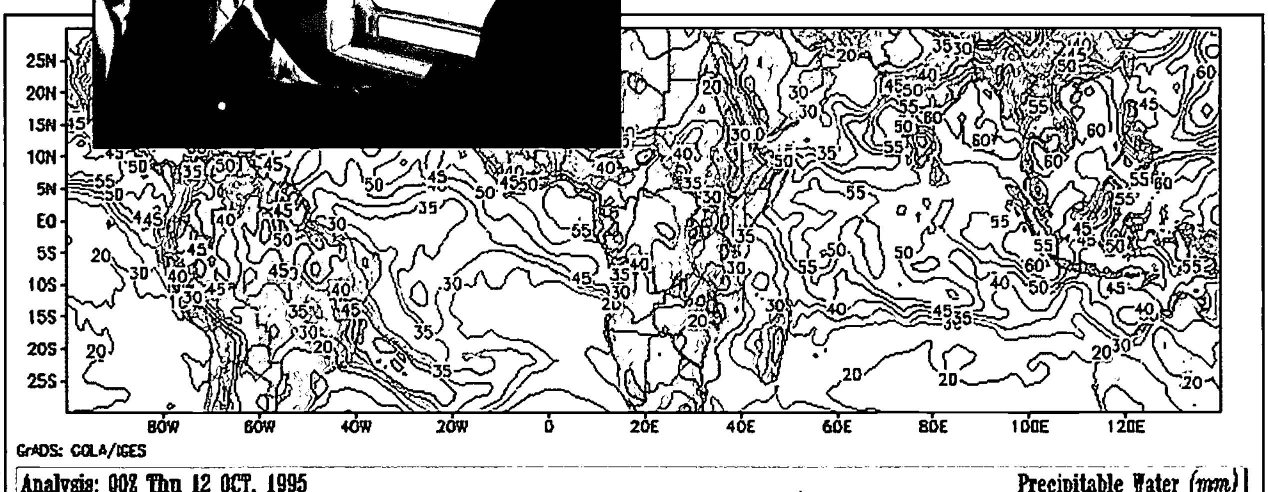
we had a tornado that killed a few people in a trailer park. Most of the time tornadoes around here don't actually touch down on the ground. Sometimes in the winter we get high winds in a snow storm, and then it's a blizzard. They hardly ever even cancel school for them, though.

Wild Winds
Gibbons School
Gibbons, Alberta, CANADA

These messages were exciting to me. Written in kidspeak—the language children use when they talk to each other—they conveyed a sense of genuine excitement and curiosity about wind phenomena. The messages also indicated to me that Michiko's group had stopped making the distinction between scientific language and colloquial language, between scientific concepts and daily observation. They were sharing meaningful, anecdotal impressions—the kind of weather information that can't be found in books!

Seven years ago, when I was working on my Colorado secondary science teaching certificate, my professors encouraged me to facilitate active student learning. My first year lessons, however, were choreographed to the minute, sometimes requiring passive cooperation from students. Although I wanted students to make choices and take responsibility for their own learning, I found that, as a beginning teacher, I needed to manage things closely to ensure classroom control and student understanding.

Working with students and the Internet has given me opportunities to reflect on and revitalize my teaching. I see the positive aspects *and* the pitfalls of using a traditional, more rigid approach. I've experimented with looser lessons and have watched students blossom and begin learning in ways I had never seen before. The Internet has helped me and my students to fulfill our potential, both as teachers and as learners.



QUESTIONS & ISSUES

BELIEFS ABOUT TEACHING

Kristine mentions that, as a beginning teacher, she wanted students to be active participants in the teaching and learning process. For the first few years, however, she needed to maintain tight control and script out student participation. What happened to change this for her? How did the process of grappling with a new technology and curriculum help her to restructure her teaching?

BUILDING ON STUDENT THINKING

Students bring to any lesson a wide variety of prior understandings, skills and beliefs. Midway through the story, Kristine realizes that the students have a preconception that data on the Internet does not relate to data they measure outside. This realization raises interesting questions about learning and teaching. What beliefs do we hold that hinder our learning in different situations? How can we uncover deep assumptions that our students may have, and how do we structure learning experiences so these belief structures become apparent to us and to learners?

EXPEDITIONS TO MOUNT EVEREST

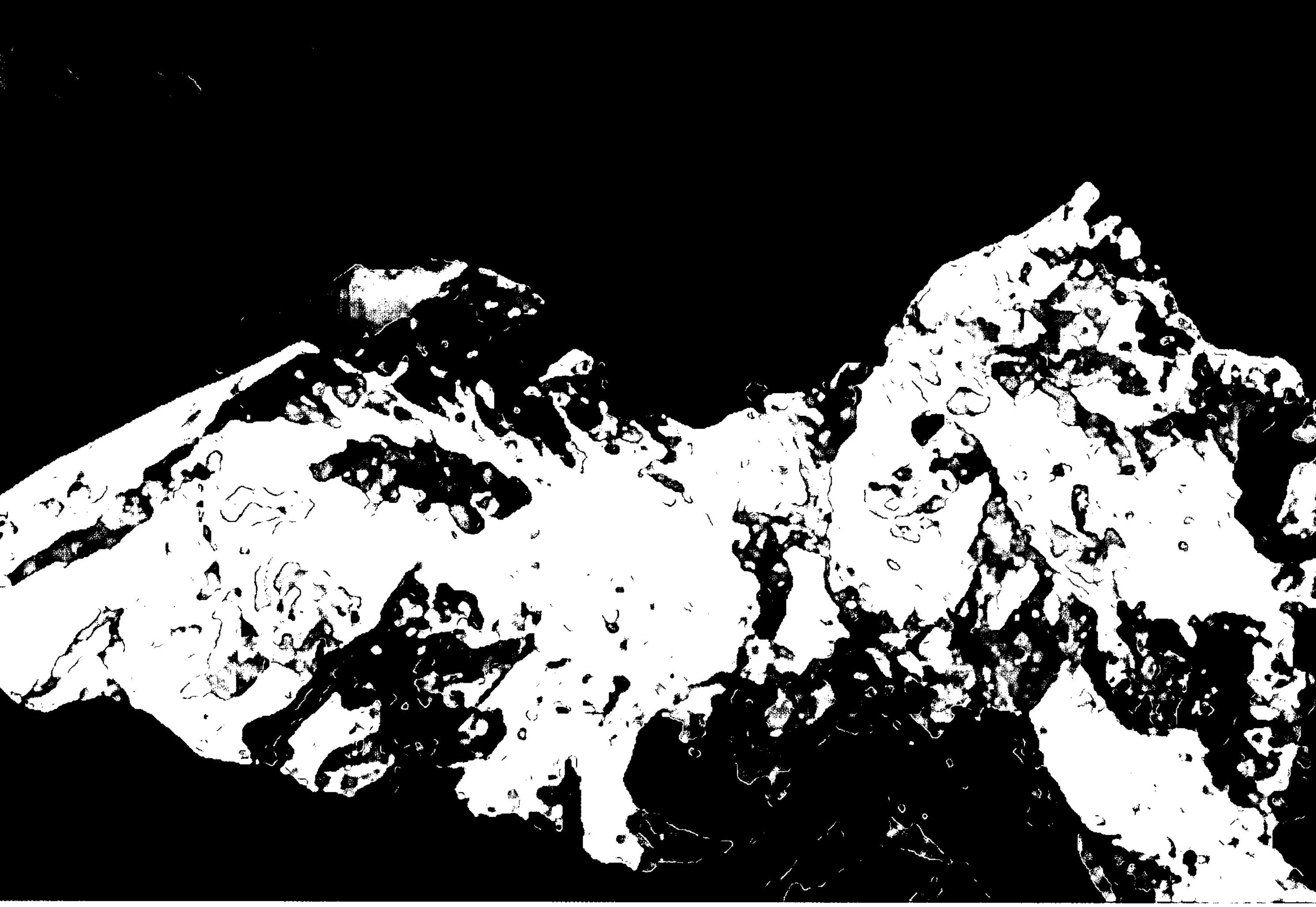
RORY WAGNER

I started doing project-based science and using the Internet with high school students three years ago. When we began I really thought I was setting them on top of Mount Everest, saying, "Look, the whole world is here for you to study. Isn't this great? Look at all the things you can explore!"

The students viewed their situation quite differently and probably would have described things more like this, "Oh my God, I could die up here. This is horrible. I'm gonna freeze to death and fall off the mountain."

I wanted students to go beyond just knowing facts and to begin asking questions about how and why physical phenomena occur. I wanted them to take more interest in and responsibility for their own learning and to become better at judging their own knowledge and understanding. These are still my goals, but this three-year journey has taught me a lot about what it takes to achieve them.

The year Lindsey, Jacob and Sean were in my Earth Science class, I began the semester with a sand analysis project. The idea was to involve the whole class in an investigation, introduce methods of data collection and analysis, and help students become familiar with the project framework they would be using throughout the class. Our school is located north of Chicago along Lake Michigan. At a nearby beach the students worked in small groups to collect and analyze different areas of sand. How fine were the grains of sand? How did the smaller and larger grains compare in terms of roundness



and smoothness? After characterizing their assigned area, students began looking for patterns from grid to grid. Did the smaller grains of sand aggregate close to the water or further away on the shore? As teams identified patterns, I moved from group to group, encouraging students to think about why a particular pattern might have occurred. At the end of the four-week project, each group completed a written report and presented their findings to the class.

Lindsey's group did solid work throughout the sand project. Both their paper and class presentation outlined reasonable, well supported conclusions and included clear explanations of their data collection and analysis methods. The students worked well as a group. Although Lindsey was clearly the leader, each student participated in group discussions and helped complete group tasks.

The class seemed ready for the next project, which allowed students to choose their own topics and identify research that interested them. Although they could have chosen new partners, Lindsey, Jacob and Sean continued to work together and chose tsunamis as their broad topic. After a week of library research, they defined a research question.

NEWSGROUPS

Newsgroups facilitate group communication about specific topics. Geometery.software.dynamic, for example, is a newsgroup in which teachers discuss instructional uses of Geometer's SketchPad and other geometry software. Newsreaders—the software needed to participate in newsgroup discussions—organize everyone's input into conversational threads and make it easier for participants to make sense of overlapping discussions.

Picking a newsreader that works for you is similar to choosing email or World Wide Web software. Start with a call to your Internet service provider. Do they offer newsgroup service? What software do they recommend and support?

Student access to newsgroups is an important and sometimes volatile issue. Although many newsgroup topics are appropriate for children, some are not. Educational organizations are developing creative ways of addressing this issue. Global SchoolNet Foundation, for example, offers a sanitized newsfeed—partial access that includes only educationally appropriate newsgroups.

For more information, contact Global School Net at:

619-475-4852

info@acme.fred.org.

Why do earthquakes create tsunamis in some instances and not in others?

It seemed like a good question. It was interesting. It involved several different content areas: physics of waves, oceanography, seismic disturbances. Most importantly, it seemed like a question that encouraged original thought, something that went beyond picking facts out of a textbook.

To answer their question, they needed to find reliable earthquake and tsunami data. Where? Following the advice of their mentors—geoscience professionals and graduate students I recruited through newsgroups—the students conducted Internet searches and checked out a few key Earth Science Web sites (see newsgroups sidebar this page, searching the Internet sidebar page 67).

After several days of searching, the students found a fantastic resource: a tsunami and earthquake database maintained by the National Geophysical Data Center in Colorado (NGDC). Each entry contained information about a tsunami and the earthquake that caused it. The data were comprehensive and included magnitude, date and time measurements taken in many different areas of the world.

	Earthquake			Tsunami	
Date	Latitude	Longitude	Magnitude	Location	Runup (meters)
2/9/91	-9.4	159.1	6.9	Solomon Islands	30
10/14/91	8.7	158.9	7.3	Solomon Islands	15
7/18/92	39.4	143.4	6.9	Honshu, Japan	29.2
6/8/93	51.2	157.8	7.3	Kamchatka	0.1
8/8/93	12.9	144.8	8.1	Mariana Islands	61.5

Lindsey, Jacob and Sean successfully downloaded the data file but could not open it. Frustrated and a little grouchy, they enlisted my help. After a few minutes of troubleshooting, I discovered that the file, although downloaded correctly, was formatted for PCs and could not be read with any of our Macintosh software. The three students perked up once the problem was identified and took things into their own hands. By contacting CoVis and NGDC staff, the students got the help they needed and soon had a Macintosh file they could read and manipulate (see CoVis sidebar page 70).

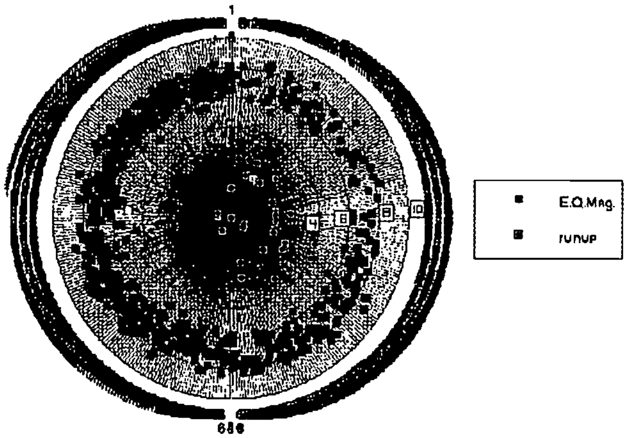
The next few class periods passed quickly and included only short conversations with Lindsey's group. Huddled together at a classroom computer, they seemed focused and animated. Since three groups were still trying to define their research questions, I ended up spending most of my class time with other students.

Three days before their Methods Section was due, Lindsey, Jacob and Sean asked for a quick conference to touch base and walk me through their analysis.

"Ok Mr. Wagner, this is what we did. We decided to work with earthquakes that occurred in the Ring of Fire. Then we dropped all the data that was collected before 1851. Those readings were missing a lot of information and it was hard to compare them."

"Great! So then what?"

"Then we made some graphs to look for relationships. This is the one we're handing in. It explains our conclusion and, besides, it looks the coolest."



The graph made absolutely no sense to me. What variables were they graphing? What was their conclusion and how did this graph support it? I also realized that the students were trying to answer their question with insufficient data. How could they compare regular earthquakes and tsunami-causing earthquakes if they had data only on tsunami-causing earthquakes?

I asked questions and pushed the group to articulate their reasoning. Other groups needed help and gathered nearby, sometimes interrupting with a quick question or cry of distress.

"Mr. Wagner, we need another mentor for our volcanoes project when you're done."

"We need help, Wags. Something's wrong with our email and it keeps bouncing back."

"Rory, we still can't find any good data for our Dead Sea project. Help!"

Everyone was starting to feel a little panicky at this point in the project cycle and the pressure was getting intense. Lindsey and his group insisted that their graph and conclusions were "on the money" and that I would understand when they finished wrinting their

(continued page 69)

SEARCHING THE INTERNET

There is a lot of information available on the Internet—how do users find the resources they need?

One strategy is to use an online search engine. These powerful computer programs are accessible through the Web and help you search the Internet for relevant information. Quick and easy to use, you simply enter key words or phrases and the search engine provides a list of relevant Internet resources.

Netscape maintains a good list of online search engines at

http://home.netscape.com/home/internet-search.html

Another common strategy is to explore an online directory. These Web sites present a wealth of online resources in an organized, well-annotated fashion. Here is information on two directories, one developed specifically for science and math educators (Eisenhower National Clearinghouse) and one designed for a more general audience (Yahoo).

Eisenhower National Clearinghouse

http://www.enc.org/

Yahoo

http://www.yahoo.com/

FOSTERING ACCEPTABLE USE

Students who are using the Internet gain access to a broader range of information and are able to communicate with a larger circle of people. As with all freedoms, these opportunities bring both educational benefits and responsibilities. What issues are school communities identifying as students go online and how are they dealing with them?

ACCEPTABLE USE POLICIES

Whether students are exchanging email or searching the Web, schools and districts are discovering the need to define norms of appropriate online behavior. By articulating expectations and consequences before students begin using the Internet, these policies—known as acceptable use policies or codes of online conduct—let students know what can and cannot be done. They also provide legal guidance and protection for school faculty and administrators.

In many ways, acceptable use policies are like field trip permission forms. Teachers consult parents and collect signatures before children leave the school grounds. Acceptable use policies are signed by parents as well as students and a school representative. For more information about acceptable use policies, see the sidebar below.

SCHOOLWIDE AWARENESS AND CONSENSUS

Without schoolwide awareness and support, even the best acceptable use policy cannot succeed. Schools and districts are discovering the need for professional development and shared decision-making. Faculty and staff need time to explore the Internet, determine how it can be used for instruction, and discuss ways of preventing and responding to inappropriate student use. These discussions can also inform development of school and district acceptable use policies and let teachers know that their opinions are heard and valued.

Parents also need to be part of the process. Many schools highlight student use of the Internet at parent nights and open houses to ensure that parents are informed of educational benefits as well as risks and preventative measures. Some schools invite a select group of parents to review or participate in development of school policies and plans.

LIMITING STUDENT ACCESS

Software and educational organizations are creating new ways of limiting student access to include only educationally appropriate resources. Some options, such as the sanitized newsfeed offered by Global SchoolNet Foundation (see newsgroup sidebar on page 66), deal with a specific Internet service—in this case, newsgroups. Other options can affect student access to many different Internet services: email, newgroups, Gopher and the World Wide Web.

Regardless of the solution you choose to implement, remember to do your research. These preventative services and software vary widely in terms of cost and the amount of initial and ongoing school support required.

MORE ABOUT ACCEPTABLE USE POLICIES

Although acceptable use policies vary from school to school and district to district, there are elements that are common to many of them.

Users agree to be:

- **Responsible**: Users who have individual accounts must use their real names (as opposed to pseudonyms) and may not share passwords with one another. They also need to accept responsibility for the content of their communications, recognizing that Internet access is a privilege that can be taken away.
- **Ethical**: Users may not interfere with other people's work or with the overall performance of the network. They may not, for example, attempt to "hack" passwords, gain entry to off-limits areas of the network, or introduce computer viruses.
- **Efficient**: Users understand that the network is a shared resource and use it in efficient ways.
- **Polite**: Users live by common rules of behavior.
- **Legal**: Users respect issues of copyright. They do not use network resources to promote illegal activities.

Some acceptable use policies, such as the CoVis Project's Network Use Policy (http://www.covis.nwu.edu/AUP-archive/AUP-1.3.html), include user rights.

Students and teachers have the right to:

- **Privacy** in their electronic communications
- **Safety** from unwanted solicitations or communications. Students are strongly discouraged from posting their home addresses or phone numbers.
- **Intellectual freedom** of personal expression

For more information, take a look at the following online resources.

Developed for teachers, librarians and other educators, **The Internet Advocate** shares strategies for guiding student use of the Internet. It also provides links to sample acceptable use policies.

http://silver.ucs.indiana.edu/~lchampel/netadv.htm

This comprehensive directory maintained at **Rice University** includes articles about developing acceptable use policies as well as links to specific examples.

gopher://riceinfo.rice.edu:1170/11/More/Acceptable

(continued from page 67)

Methods Section. After ten minutes of circular conversation, I gave up and suggested that they rethink their approach and get feedback from another group of students.

This conversation continued for another week as the three students completed their report. The results were unchanged: same data, same graph.

At the time, I saw this project as a personal failure and really took it to heart. With better guidance, the students might have realized they were working with insufficient data. But I soon came to realize a lot more was going on. I knew that shifting from traditional learning to discovery would be hard. The teacher's challenge is to manage a delicate balance: structuring opportunities that engage students in their own process of inquiry while not paralysing them with freedom shock. In this case, however, dynamics I hadn't anticipated and didn't fully understand conspired to make it harder.

First, the sand project hadn't really prepared the students for their deeper immersion into independent work. I suspect that the graphing exercise was too structured, leaving them ill-prepared to create and interpret graphs in their next project. More importantly, there were big differences in the nature of the data used in the two projects. In the sand project, students dealt with familiar objects—sand—and collected the data themselves. The earthquake/tsunami project, however, led Lindsey's group into unfamiliar territory. Since the students had never experienced an earthquake or tsunami, they had no concrete experiences or intuition to draw upon.

I also learned that, ironically, technology may make it harder for high school students to develop the skills they need to analyze data well. Through the Internet, they can access an impressive, perhaps even overwhelming, amount of high quality data. Yet this amplitude—the very asset that enables them to pursue their own research questions—can work as a drawback. The students got caught up in their newfound ability to access and exhibit that data in ways that appeared very scientific, causing them to pay less attention to critically examining messages in the data. Thus graphing becomes a "cool" way of displaying data rather than an important analytical tool in answering a particular question. This is partly why Lindsey's group began to clutch at their graph. Beneath the flurry of activity and their uncertainty lurked the assumption: "We're using real scientific data; we must be doing real science."

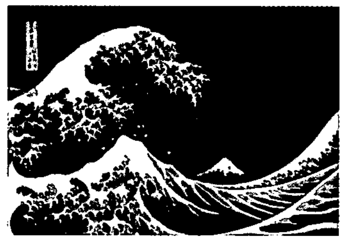
Although their data analysis was weak, Lindsey's group demonstrated other skills and knowledge. They worked collaboratively to solve large and small problems relating to their research. They learned to use many different computer tools, and the Internet gave them quick access to data not available locally. They used email to communicate with Earth scientists in distant places, getting sugges-

EARTH SCIENCE RESOURCES

Scientific research organizations provide lots of Earth science images, datasets, and visualization tools via the Internet. Here are three comprehensive sites that offer educational resources for elementary, middle and high school students and teachers.

Offering more than just maps, the **United States Geological Survey (USGS)** provides Earth science data, images and curricular resources for K-12 teachers and students.

http://www.usgs.gov/



The **National Geophysical Data Center** provides numerous comprehensive datasets and visualization software packages in the fields of geophysics, climatology and glaciology.

http://www.ngdc.ncaa.gov/

Developed by a team of teachers and research scientists, **Volcano World** provides K-12 curricular resources, updates on volcanic activity and access to practicing volcanologists.

http://volcano.und.nodak.edu/

COVIS

Learning through Collaborative Visualization (CoVis) is an electronic community of high school students and their teachers, scientists and educational researchers. CoVis students study atmospheric and environmental sciences through inquiry-based investigations. Using state of the art scientific visualization software modified for high school use, students have access to research tools and data used by leading-edge scientists.

Participating teachers receive curricular and technical support as well as opportunities for professional development. The CoVis community also maintains a directory of activities, student projects and online resources in the geosciences. Together, project participants and staff seek to understand how science education can best utilize networking and visualization tools in a project-based science learning environment.

For more information, contact CoVis at:
info@covis.nwu.edu
http://www.covis.nwu.edu/

tions about what kind of data they would need and where to find it. Building on this, the next time out we overcame some of the stumbling blocks.

Lindsey, Jacob and Sean chose to work together again in their next project, an investigation of man-made satellites. This time, all four of us had a better idea of how long data analysis could take and how difficult it could be. Not wanting a repeat of the last project, I insisted on having detailed conversations with them earlier, before they completed their analysis and developed conclusions. Touching base at regular intervals, we worked on the analysis together. I asked them to define their approach before they started making graphs, helping them to refine it until all four of us felt comfortable. When they finally began graphing their data, I pushed them to start with simpler forms such as bar and line graphs. We also talked through key questions for each graph. What variables were being graphed? What relationships were becoming apparent? As Lindsey's group worked on their analysis, I pushed them to understand what each graph represented.

As I work with other students, I often think of Lindsey, Jacob and Sean and remember the lessons we learned together. For me, the key point is the importance of fostering and appreciating incremental change. Changing the way you teach takes time and is often a messy and difficult process. It requires tinkering, reflection and, above all, negotiation. Students have ideas of their own—ideas about science, about technology and about the process of learning. To truly model the spirit of inquiry, it's important to find out what they think and actively work with them to discuss and rethink these ideas. Regardless of what approach my students and I take and what technologies we use, the point is that, together, we are learning to learn.

QUESTIONS & ISSUES

LIMITATIONS OF THE INTERNET

The high school students in this story experience difficulties that are common to students of all ages. Although they are skilled at finding relevant information, they have a hard time synthesizing and making sense of it.

How does using the Internet benefit and hinder students with this profile? How can teachers communicate the importance of questioning and analyzing information? How can they help students to develop better inquiry and analysis skills?

TEACHING AS RESEARCH

Several teachers read drafts of this story and noted that the author deals with both student and teacher research. The students investigate scientific phenomena, finding and making sense of their earthquake and tsunami data. The teacher, on the other hand, explores questions about how to best foster student learning. How might the sand project be changed to improve student graphing and analysis skills? How do student views of information taken from the Internet influence their ability to question and probe?

WHY GRAPH?

What understanding—and misunderstanding—is demonstrated in the student graph? What assumptions and attitudes do the students reveal as they discuss the graph and their conclusions with the teacher?

For many students, graphing is a difficult part of doing science. Knowing this, the teacher in this story created opportunities for students to make and interpret bar and line graphs. Why, then, did Lindsey's group have problems analyzing their earthquake/tsunami data? How might students' lack of familiarity with these phenomena have influenced their performance?

ABOUT THE AUTHORS

BILL BARNES

Bill Barnes taught math and science for five years at Seattle Country Day School, a private school for intellectually and creatively gifted students.

Currently, he is helping to develop curriculum for the Live from Earth and Mars Project and is working with NorthWestNet, a regional Internet connectivity provider. He is also exploring new areas of interest and would like to pursue a career in radiology.

Bill enjoys spending his spare time outdoors and can often be found sailing in his boat or biking along mountain trails in the Northwest. His favorite thing to do at the end of a long day or week is to watch Star Trek and eat Ben and Jerry's Rain Forest Crunch ice cream.

SUSAN HIXSON

Susan Hixson's fascination with technology began in 1981 when she learned to play PacMan to better communicate with her son. This experience shaped her thinking about how technology can be used to reach young people. She is currently a staff developer with the Tempe Elementary School District in Arizona and, in her new role as Internet Specialist, is working with other teachers to explore ways of using this technology to improve student learning.

Susan maintains a homepage of Internet resources to help Tempe teachers find curricular resources quickly (**www.indirect.com/www/dhixson/travel.html**). She also publishes a weekly newsletter to inform her colleagues of upcoming Internet projects and new addresses.

Originally trained as a Reading Specialist, Susan continues to be interested in enhancing language skills through all areas of the curriculum. She enjoys exchanging ideas through informal discussions, publications and conferences.

GLENN LIDECK

Glenn Lidbeck teaches fourth grade at Essex Elementary School, a public school which serves approximately 500 K-6 students from the villages of Centerbrook, Ivoryton, and Essex, Connecticut. He just completed his first year of teaching after serving ten years in the Air Force. Glenn has found computers to be a dynamic addition to the class environment and sees the Internet as an exciting new frontier for education. He and his students will be participating in several telecommunications projects during the 1995-96 school year, including GlobaLearning Virtual Field Trip and Math Online, an America Online Electronic Schoolhouse Forum.

GREG LOCKETT

Greg Lockett teaches science at Cottonwood High School, a small high school in a rural area of Northern California.

Currently beginning his twenty-first year of teaching, Greg began his career teaching a fifth through eighth grade combination class. There he discovered the utility of a project-based approach as well as his love of science. He went on to pursue a bachelor's degree in chemistry at the University of California, Berkeley and worked as a research chemist at Lawrence-Berkeley Laboratory.

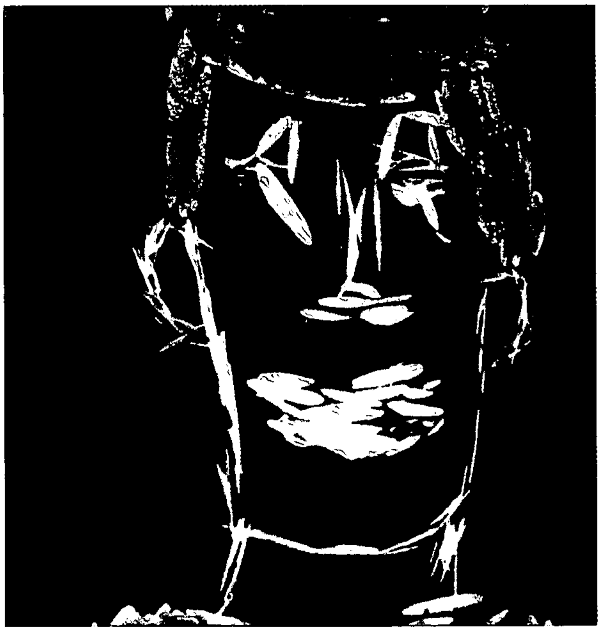
Greg has participated in numerous projects that have a telecommunications component, including Global Lab and LabNet. He is currently authoring materials for Hands-On Physics, a two-year, multimedia physics program for high school seniors and college freshmen being developed by the Concord Consortium in Cambridge, MA.

For re-creation, he hikes with his wife, Sydney, in the natural beauty of nearby Lassen Park and along numerous trails surrounding Mount Shasta.

LINDA MASTON

Linda Maston teaches eighth grade Earth Science at Pease Middle School in San Antonio, Texas. She began using telecommunications for instructional and professional purposes in 1990. Her classes became the first in San Antonio, and among the first in Texas, to use telecommunications as an integral part of the curriculum.

Linda graduated from Eastern Washington University with degrees in geology and physical geography. She is active in



various science teacher organizations, particularly the Texas Marine Educators Association. She is involved with several national teacher enhancement projects as well as GLOBE and the Global Lab Project.

When she's not online, Linda is a very avid sand collector. She also enjoys hiking, camping, reading, and putting geology maps into cross-stitch embroidery for clothing.

KRISTINE MUEH

A Colorado native, Kristine Mueh attended the University of Colorado in Boulder where she received her bachelor's degree in molecular, cellular and developmental biology and completed requirements for the Colorado secondary science teaching certificate.

She continues to live in Boulder and has taught science at Centennial Middle School for the past six years. She also coaches debate at Boulder High School. A longtime proponent of instructional technology, Kristine's interest really took off when Centennial's computer lab first got its direct Internet connection.

Kristine enjoys outdoor activities and often goes skiing, biking, rollerblading, or just hiking with a good book into Boulder's open spaces!

KAREN NISHIMOTO

Karen Nishimoto teaches at Punahou School, an independent college preparatory school in Honolulu, Hawaii. She has a master's degree in plant pathology and taught college and high school before finding her niche working with seventh and eighth grade students. After using the Internet for instruction and professional dialogue, Karen is convinced that it has enormous potentia to facilitate student learning in science.

An Internet newcomer, Karen received extensive training during the 1995 AT&T Teachers and Technology Institute. She has conducted Internet workshops, serves as a mentor teacher for AT&T's Learning Network, and is currently working on inquiry-based science curricula that use the Internet for discussion and data exchange.

RORY WAGNER

Originally trained as a geologist, Rory Wagner teaches Earth Science at New Trier High School in Wilmette, Illinois. He serves as Earth Science Coordinator, CoVis Technical Coordinator, and has taught at New Trier for 22 years.

Rory also holds a master's degree in geology and has done graduate work at Northeastern Illinois University in Chicago and the University of Alaska at Fairbanks.

A former football and lacrosse coach, Rory enjoys the outdoors and makes a yearly trek to Alaska with his wife, Katie (a high school dance teacher) and their two Belgian sheepdogs, Chena and Kenai. Big dog-lovers, Rory and Katie plan to get two more dogs and have already picked names Denali and Kodiak.

JOANNA YANTOSH & CAROLINE BRENNAN

Formerly known as the Hughes sisters, Joanna Yantosh and Caroline Brennan are teaching colleagues at Drexel Hill School of the Holy Child. An independent Catholic school just minutes away from Philadelphia, Pennsylvania, Holy Child is co-ed and serves 224 students in grades pre-kindergarten through eight.

Joanna and Caroline are Holy Child veterans and have taught at the school for eight and fourteen years respectively. Both sisters teach fourth through eighth grade math and seventh grade reading. Joanna also teaches eighth grade social studies and serves as math chairperson.

The two women enjoy learning new things about teaching mathematics and have participated in many classes together. They first learned about the Internet in 1993 through Using Internet With Mathematics, a workshop conducted by the Geometry Forum. They continue to be very active in the Forum community and first learned about the Math and Communications Project through Forum staff. Joanna and Caroline have found Forum staff to be extremely helpful and strongly recommend that teachers interested in geometry contact them and see what they have to offer!

Joanna resides in Brookhaven with her husband, Ray, and her two sons, Raymond and John Paul. Caroline lives in Drexel Hill with her husband, Tom, and daughter, Carrie.

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...an excellent, thought-provoking resource for teachers, curriculum and technology specialists and principals. Tales gives you ideas about what's available and how the Internet can be used for instruction.

Jean Lakata, middle school science teacher

The stories were clear and easy to read. I really liked the fact that they weren't just about the Internet. The stories brought up educational issues being talked about in science and mathematics education.

Karla Ball, third grade teacher

There were stories that made me feel at home: inner city kids, old computers, and a small science budget. After reading Tales, I know more about what can be done and how to start. I want to get involved in this right away!

Susan Floore, middle school science teacher

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